LEEDS PHILOSOPHICAL AND LITERARY SOCIETY.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVIII. MAY 13, 1898. No. 7

Sir R. S. BALL, LL.D., F.R.S., President, in the Chair.

George Banaster, The Mythe Villa, Tewkesbury ;
Edward I. Essam, Billingborough, Lincolnshire ;
The Hon. George Stuart Forbes, I.C.S., Revenue Secretary to the Government of Madras, Madras, India ; and
The Rev. William Edward Winks, 58 Richmond Road, Cardiff, South Wales,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Cecil Goodrich Julius Dolmage, M.A., LL.D., 22 Upper Merrion Street, Dublin (proposed by J. E. Gore) ; and
Andrew Ellicott Douglass, B.A., Lowell Observatory, Flagstaff, Arizona, U.S.A. (proposed by T. J. J. See).

Seventy-five presents were announced as having been received since the last meeting, including, amongst others :—

Harvard College Observatory Circular, No. 28 ; Photographic Spectrum of the Aurora, presented by the Observatory ; T. R. Dallmeyer, A simple guide to the choice of a photographic lens, presented by the author ; Two photographs of the total solar eclipse of 1898 January 22, taken by the Lick Observatory Expedition (lantern slides), presented by the Lick Observatory.

Vanadium in the Spectrum (C to D) of Sun-spots. By the Rev. A. L. Cortie, S.J.

In a former paper, entitled "Observations of the Spectra of Sun-spots in the region B – D" (*Memoirs R.A.S.* vol. l. p. 51), I called attention to a line near w.l. 6243·5, which was only just visible in the ordinary solar spectrum, but was very greatly widened when it crossed a spot. Since the publication of this paper my observations of the spot-spectra have been somewhat desultory, but in those which I have secured this line has been always most marked, being one of several faint lines in this region which are permanent and characteristic of the spectra of all spots. That this judgment is unbiassed is evidenced by the fact that, after a long break in the observations, when the region had become less familiar to me, and I had frequently to consult Mr. Higgs's beautiful maps while observing, the same line always claimed attention. The publication of Professor Rowland's "Preliminary Table of Solar Spectrum Wave-lengths" in the *Astrophysical Journal* has enabled me to fix the widening as almost certainly due to the very faint Vanadium line at 6243·055. The line is invisible in the ordinary spectrum with the Browning 12-prism spectroscope, but it can be seen in the second order of the grating spectroscope, and on 1891 September 7 over a spot, when it was clearly separated from the adjoining line at 6243·32, it was very much widened. Hence I conclude that the remarkable widening of the line, seen only across spots with the prism spectroscope in this position, is due to the Vanadium line. Moreover, its sympathy with the widening of other lines due to this metal is a further proof of its identity. Among such is a faint line at 6039·953 which is also much widened in all sun-spots. This has led me to study the behaviour of all the Vanadium lines catalogued in Professor Rowland's lists between C and D in the spectrum of sun-spots. The results are collected in the following table :—

No.	Rowland Wave-length.	Inten-sity.	Thalèn Spark.	Inten-sity.	Relative Mean Widening.	Remarks.
1	6039·95	0	6040·3	10	15	Always widened.
2	6081·67	0	6081·3	4	5	
3	...	...	6090·3	10	...	? 6090·43 Fe.
4	6111·87	0	6110·7	4	7	Sometimes with Ni 6111·29.
5	6119·74	1	6120·2	10	5	Sometimes with Ni 6119·97.
6	6135·58	00	6135·6	4	10	Very near Cr line 6135·99.
7	6150·36	0	...	...	9	
8	6170·42	0000	...	...	...	Not seen.
9	6199·40	0	...	...	15	Always widened.
10	6214·08	000	...	...	...	Not seen.
11	6224·72	000	...	...	...	Not seen.
12	6230·94	8	...	...	5	V and Fe.
13	6243·06	000	6241·8	6	40	Always very much widened.
14	6252·05	00	...	...	10	
15	6258·57	000	...	...	9	With Ti line 6258·32.
16	6261·50	0000	...	...	9	With Ti line 6261·32.
17	6269·08	000	...	...	30	From 4 observations only.
18	6285·38	00	...	...	...	Observed once.
19	6293·03	000	...	...	...	With O line 6293·17. Widened once.
20	6296·58	0000	...	...	...	Not seen.

The intensities of the solar lines in the third column are taken from Rowland's lists, in which a line of intensity 1 is one that is just visible on his Map of the Solar Spectrum, while intensities 0 to 0000 indicate increasing degrees of faintness. On this scale the lines C, D_2, and D_1 are of intensity 40, 30, and 20 respectively. In the fourth column are given the corrected wave-lengths of the lines of the metal observed in the spark by Thalèn, taken from Dr. Watts's "Index of Spectra," and in the next column their intensities, on a scale 1 to 10. The line 6090·3, which is one of the strongest in the spark according to Thalèn, seemingly does not appear among the solar lines. There is an iron line at 6090·43. In the fifth column is given the relative mean widening of the lines, which is an estimation of their approximate order in the spot spectrum. The want of correspondence with the normal intensities of the lines is apparent. The numbers have been obtained by taking means of all the observations of the widenings of the lines, reckoned in terms of the normal width of the lines in the ordinary spectrum and multiplying the results by 10. Thus 15 means that the line is, on an average, one and a half times as wide again in a spot as in the ordinary spectrum.

All the lines in the list are, with the one exception of a line coincident with an iron line, faint or very faint lines. Three of the faintest of all have not been observed, and five others cannot generally, with the dispersion employed, be separated from lines due to Ti, Ni, and O, which adjoin them. But the lines numbered 1, 9, and 13 are always widened in both maximum and minimum period spots. The line numbered 9 has near it two lines of the same intensity in the ordinary spectrum at positions 6194·63 and 6195·67. In observing these three lines over spots, although out of the spot they are of the same intensity, yet in the spot the Vanadium line is greatly widened, while the two others are unaffected. Such was the case, to give instances, on 1894 November 30 and December 12, and on 1896 November 6, when, at a time when the light did not allow of the lines being seen in the ordinary spectrum, the Vanadium line alone stood out where it crossed the spot, and later on, when the seeing improved, the Vanadium line was alone widened in the spot, the companion lines remaining unwidened. This is a case in which, of lines of the same intensity and near to one another, one is affected in spots and others are not, thus proving that the phenomenon observed is objective, and not merely optical and subjective. To take another example. At 6306·02 and 6306·78 are two lines of exactly the same intensity, according to Rowland and Thollon. The former of these two is both constantly and greatly widened in sun-spots, the latter never. Both these lines are due to atmospheric oxygen, yet in Thollon's map the line widened in sun-spots is, curiously enough, indicated as a solar line. Unless the widening of 6306·02 is due to some very faint solar lines on either side of its position, which with the dispersion employed would be coincident with it, the widening of this oxygen line would indicate the presence of the gas in sun-spots. Moreover, No. 19 in the list of Vanadium lines, which is a very faint line, is not two-tenths of a Xth metre removed from another oxygen line. The line at this wave-length was widened over a spot on 1896 November 8. If the oxygen line was unaffected, then the widening must be attributed to the very faint Vanadium line adjoining it. Similar remarks apply to the five lines in the above list which are close to Ti, Ni, and Cr lines. Indeed, in observations of this sort, in regions where the lines are closely packed together, unless a very high dispersion be employed, it is extremely easy to attribute the widening to lines of some particular metal, when in reality it belongs to some faint line which, with the dispersion employed, is coincident with a neighbouring line.

With regard to the presence of Vanadium in sun-spots, as indicated by the widening of these faint lines, it is noteworthy that its combining weight, 51·3, is very close to that of titanium, iron, nickel, and other elements about this atomic weight, which also are marked constituents of sun-spots. Its behaviour is very like that of the faint lines of titanium. This suggests that the

level of sun-spots is possibly the level of the faint lines of such metals as have an atomic weight about 50. To the objection that the lines of metals like calcium and sodium and the lines of hydrogen are also present, the answer seems to be that such elements are not confined to sun-spots, but extend to a great height in the solar atmosphere. Moreover, broad lines, like H and K and the C line, are generally reversed in the region about sun-spots, and the D lines frequently so. Two Vanadium lines in the region under discussion occur in Professor Young's list of chromospheric lines, but one of these is the close double due to Fe and V, which is one of the least widened of all the lines in sun-spots, No. 12 in the table, and is also the most intense of all the lines of the list in the ordinary spectrum; and the other, 6216·5, is not attributed to Vanadium in Rowland's Table. This line, however, is sometimes much widened in sun-spots; but, being of intensity 1, though a faint line, it would be one of the strongest lines of the list, if it is really a Vanadium line.

Stonyhurst College Observatory:
1898 *May* 7.

Notes on the Zodiacal Light. By William Anderson.

Mr. E. W. Maunder's note on the Zodiacal Light in the *Monthly Notices* for March has been of much interest to me, for since I first came to Madeira in the winter of 1895-96 I have given more or less attention to it, so far as delicate health and the difficulty of obtaining a clear western horizon admitted, and have arrived at conclusions somewhat different from his. Situated as I am, it has been impossible for me to examine directly either the results or conclusions of other observers, and this must be my apology if the results presented in this paper do not contain anything new. I had intended not to publish my conclusions until I had arrived at something more definite, but there are one or two points in Mr. Maunder's paper to which I wish to refer, besides which I have arrived at the conclusion that the mystery which surrounds the Zodiacal Light will never be cleared up until systematic observations are simultaneously undertaken at a number of different stations both in the northern and southern hemispheres. I have shown in the *English Mechanic* of 1896 July 17 that the variation in the appearance of the light from night to night is largely, if not entirely, due to atmospheric causes; and, as I shall endeavour to show presently, it is necessary to have simultaneous observations from several stations in both hemispheres before we can decide whether the appearances presented by the light are due to a deviation of its plane from that of the ecliptic, or solely to atmospheric absorption.

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Mr. Maunder has supposed the light to consist of a disc of matter lying within the Earth's orbit, while a good way outside the Earth's orbit there exists a flat ring of matter reflecting the Sun's light. In the accompanying diagram (fig. 1) let the inner

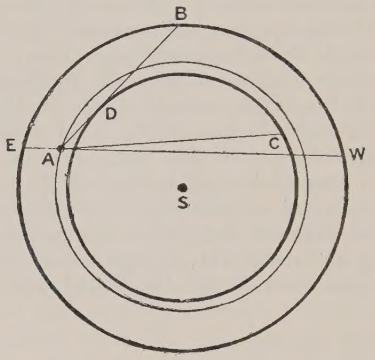

Fig. 1.

circle represent the outer edge of the inner disc of light, the middle circle representing the Earth's orbit, and the outer the "flat ring" of light, A being the Earth and E W the horizon shortly after sunset. Obviously we should see the light from the inner disc extending up from the horizon, its apex being projected on the sky in the direction A B. This disc will be brightest at its base, where, in the direction A C, we look at the particles of matter about C, which are most nearly "full," and it will fade somewhat gradually upwards, its apex at D being faint and indefinite because the particles of matter at this point will be more or less "new." Immediately above the apex of this inner light we see the outer ring at B, and from its being enormously distant at this point the ring will appear narrow and comparatively faint on account of the gibbosity of its particles. As we approach the zenith the ring will become broader, since it comes nearer to the Earth, and brighter as its particles become more "full," until at opposition to the Sun it assumes its maximum breadth and brightness. So far as I am aware, no such appearances have ever been observed, but I may be mistaken. The fact that Mr. Maunder observed the apex, not of the brightest portion of the light, but at any rate of a brighter portion of it than occurred at opposition to the Sun, at a distance of 164° from the Sun in December, and 102° in February, shows that no such break in its continuity occurred at the point B, as might have been anticipated.

In 1896 February I frequently observed the apex at a distance of 105° from the Sun; by the beginning of April it had shrunk to 70°; throughout April to 60°; on April 28, 65°; on

July 3 (a doubtful observation), 75°; and on the morning of November 14 to 85°. Throughout all this time I had often endeavoured to see the "Band" and the "Gegenschein," but never succeeded in observing either. Ill-health in the spring of 1897, and the fact of my being in Ireland during the summer, prevented observations until my return in November last. On the evening of November 13, at 7.30 P.M., I was taking a preliminary survey of the sky in order to refresh my memory in regard to the constellations and stars previous to keeping a watch for the *Leonid* meteors when what I have described in my notes as a "hazy, nebulous band" caught my eye somewhat to the east of the meridian. I had not been thinking of the Zodiacal Light at all, and this band, which I had never seen before, was fairly conspicuous. I settled its position with regard to the stars, and found on referring to the maps that it practically coincided with the ecliptic. The Zodiacal Light in the west at the time was visible as a mass of light without any definite borders or apex, so that I could not see whether the band was a continuation of the brighter light or not, *i.e.* whether the axis of the light also lay in the ecliptic, but the band passed about midway between the *Pleiades* and *Aldebaran* on the east. Since then I have seen the band on November 23, when the apex of the brighter portion of the light was 80° distant from the Sun, and on December 14, when the apex of the cone of western light was 105° from the Sun. More recently, on April 15 last, I failed to find this band; but the atmosphere seemed thick, and on the following evening (the 16th) I found the brighter western portion a shapeless mass of glowing light extending to about 60° or 65° from the Sun, and from this I clearly traced the band right across the sky, its breadth being 5° or more. The following stars lay, as nearly as I could estimate, upon its axis; but from the fact that its light was so faint that it could not be seen at all when looked at directly its axis as here indicated may easily be 3° or 4° in error.

Between κ and δ Geminorum	θ Virginis
δ Cancri	Between ι and κ Virginis
31 Leonis	,, α and β Libræ.

It therefore seems to lie entirely to the north of the ecliptic, the light of *Regulus* having evidently affected my estimate of its position in this neighbourhood. Last night (April 17) I again saw it in identically the same position. To make absolutely certain that I was not deceived—for its faintness is such that unconscious deception might readily occur—upon three different occasions between 8 and 10 o'clock I swept over it to the north and south with an opera glass, in different portions of the sky and without having first looked for it, and upon each occasion I readily located it correctly, being conscious of having run the glass across something which I could not see when looked at

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directly. Now, the fact that I never saw this band in 1896, when I had often looked for it, but picked it up when nothing was further from my thoughts in 1897 November, strongly supports Mr. Maunder's conclusion that the Zodiacal Light is at present brighter than usual. But I have certainly not observed this to be the case with the cone proper, and had, indeed, decided that it was more brilliant in the spring of 1896 than now.

If we suppose the Zodiacal Light to be a flat luminous ring extending continuously from the neighbourhood of the Sun to a short distance beyond the Earth's orbit (fig. 2), then, looking

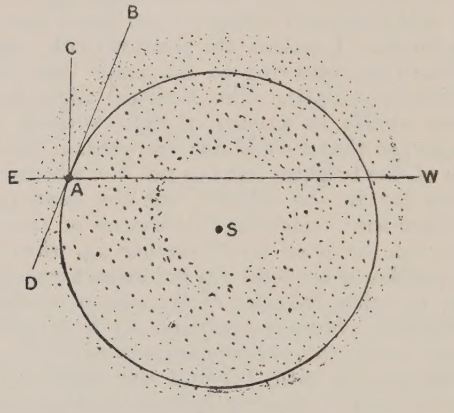


FIG. 2.

along the horizon shortly after sunset, we shall be looking through a vast number of particles of matter more than half of which, viz. those farthest away from the Earth, are almost "full," their light being diffused, and the definiteness of the edges of the further side of the ring being obliterated by the nearer, and therefore *broader*, mass of particles which turn a very small crescent of their illuminated hemispheres to us. As we view the Light further up from the horizon we at length come to a point, for example, between B and C, at which the extra quantity of more or less gibbous particles through which we look exactly counterbalances the smaller quantity of "fuller" particles on the side of C next E, and from this point we shall have a practically uniform band of light down to the horizon at E. After some hours the apex of the cone at B will sink below the horizon, which is then represented by the line B D, and we shall have nothing but the band remaining until the opposite process begins to take place on the eastern horizon before sunrise. Mr. Maunder states that "if the Light were due to a disc of matter extending uninterruptedly outwards from the Sun to a considerable distance beyond the Earth's orbit . . . the opposition portion

would tend to appear much broader than is actually the case." This, I think, would only be so if we assume a greater thickness for the disc than is necessary, or indeed probable, at its outer edges. Let fig. 3 represent a section of the outer border of the Light at right angles to the ecliptic, the Light having a thickness of, say, 10,000 or 15,000 miles where the Earth, Y, is immersed in it, and tapering off towards the edge, it is quite possible that we shall only see a thickness of it sufficient to render its feeble light visible at all when we are looking toward that part of it which is included in the angle X Y Z, say a band about 5° or 10° wide, its edges being, as is actually the case, quite indefinable.

This view satisfies all the existing visible facts as to the intensity of the Zodiacal Light, so far as I am aware, except perhaps that of the Gegenschein, a phenomenon which I have often carefully sought for, but have never yet seen, although I do not see how it could have escaped me had it existed since my observations of the Light began.

Fig. 3.

But it is quite possible that the Zodiacal Light does not everywhere extend beyond the Earth's orbit, and it is here, and when we come to deal with the plane in which it lies, that simultaneous observations in both hemispheres are necessary. As I have already shown, the Light is readily overcome by atmospheric absorption, so that when it rises from the horizon at a less angle than 90° that border of it which is nearer the horizon is liable to, and must, become more or less obliterated, throwing the axis of the visible cone to one side of its real position. Mr. Maunder says, referring to his observations of February 16–21, "The heliographic latitude of the Earth was then 7°·2 S. If, therefore, the disc extends to within a few million miles of our orbit, and if it lie in the plane of the Sun's equator, it should have shown an enormous displacement to the north of the ecliptic, which was most certainly not the case. In fact, the light appeared, if anything, to lie further south in February, when the Earth was at its maximum south heliographic latitude, than in December, when its latitude was only 3°." This last observation is exactly what we should expect if the light lie in the plane of the Sun's equator, for it is not, as Mr. Maunder appears to have assumed, those particles of matter lying between us and the Sun which give out the great portion of the visible Light, but those more or less on the further side of the Sun, as, for instance, those

near W, fig. 2. In December, however, Mr. Maunder's observations clearly show that the Light lay as nearly as possible on the ecliptic, when, if it lie in the plane of the Sun's equator, it should have been, in the evening, a long, narrow cone the apex of which lay below the ecliptic, and the axis of which was inclined to it, and crossed it at about the Sun's place. For if the plane of the Light be in the plane of the Sun's equator we should see, in the evenings, a long, narrow beam of Light in November and December the apex of which would lie to the south of the ecliptic, the Light being brightest at its centre, and fading off about equally towards both its northern and southern edges. It should then grow broader until about the beginning of March, its southern edge being brighter and better defined than its northern, because of its particles being at the further side of the Sun, and consequently being almost full, and of its increased narrowness through distance, its apex lying more or less on the ecliptic. It will again become narrow until about the end of May or beginning of June, its apex now lying to the north of the ecliptic, and its edges equally defined, and then it will grow broader until September, its northern edge now, however, being the better defined, and its apex again coinciding roughly with the ecliptic. The position of the apex, however, may vary considerably, depending largely, as it will, upon the relative densities of the outer and inner portions of the ring; and as the particles of which the Light is composed must be in constant motion, and continually taking up new relative positions, the apex may be expected to shift both in longitude and latitude within certain limits.

My observations given below, fragmentary though they be, go some way towards strengthening this view. The base of the Light most certainly becomes broader and narrower in a way which I cannot explain if the Light lie in the plane of the ecliptic.

Piazzi Smyth, in a paper published in 1852 in the Transactions of the Royal Society of Edinburgh, vol. xx. Part III., states that during the whole period of summer in the northern hemisphere, during which the Light was invisible to Cassini, it was most visible at the Cape. Cassini, he states, believed its invisibility in summer to be mainly due to the long twilight. "But these ideas (of Cassini), on being tested by the Cape observations, completely fall to the ground; for during the *whole* period of invisibility to Cassini (caused in reality by the lengthened twilight of summer in his northern hemisphere) the phenomenon was most visible at the Cape, as winter then prevails in the southern hemisphere; and, indeed, the very reverse effect from that expected by Cassini should follow when a transparent and oblate luminous ring is viewed in profile, for it will then be seen at its brightest, on account of all the infinitely small light-giving particles being brought closer together." But what Cassini contended was that the Light *should* be visible in the winter of the southern hemisphere, so that how his ideas fall to the ground

does not appear. Besides, when we see the ring edgewise, we are looking at the further and brighter portion through the entire mass of particles which are almost "new," and it therefore does not follow that the ring must be brightest when thus seen.

I believe that a series of observations carried on simultaneously at several favourably situated stations in both hemispheres could not fail to definitely settle, at any rate, the form and plane of the Zodiacal Light. Is it not of the greatest importance to ascertain the nature of matter, in which we probably live and move and have our being, which we may be actually breathing into our lungs—matter probably having a diameter of not less than 200 millions of miles, and yet incapable of obliterating the light of the faintest stars, except when it shines, which it sometimes does and sometimes does not? Telescopes and cameras have photographed stars through the Zodiacal Light and Band again and again, and yet not a trace of either appears upon the negatives, although they are visible to the unaided eye! Photography would, no doubt, yield good results in determining the axis of greatest brightness in the neighbourhood of the eastern and western horizons, but it does not seem to be capable of yielding any results with regard to the fainter extensions of the Light.

Date.	Hour.	Position of Apex.	Brightest or Best Defined Border.	Width of Base.	Distance of Apex. from Sun.	
1896.		h m °			°	
Feb. 1	7.15 P.M.	R.A. 3 40 Dec. +20		Indefinite	105	
3	7.15	3 40 +20		15° at ♈	100	
6	7.0	2 40 +15	South	30°	85	
6	8.0	4 0 +20			105	Appears conical, not lenticular.
9		1 40 +10		Indefinite	65	Faint.
March 3	7.15	3 40 +20		50°	75	Very bright.
8		3 40 +20	South		70	The faint, diffused north edge extended much farther north of the ecliptic than did the southern brighter edge south of it. Passed nearer α Arietis on N. than ζ Tauri on S. Apex indefinite.
April 3	8.45	ζ Tauri	South	30°	70	Pleiades in centre of cone.
9	8.30	ζ Tauri		Indefinite		„ „ „
10		Just N. of ζ Tauri		Very diffused	60	Light very diffused.
13				Faint and diffused		Very faint and diffused. Could make nothing of it.
28	8.0	δ Geminorum		Invisible in haze	65	Base appears to lie north of ecliptic.
July 3	9.0 P.M.	h m R.A. 11 40 Dec. +5		8°	75	Base lies between α and γ Leonis, apex about half-way between β and ν Virginis. Extremely faint.

Date.	Hour.	Position of Apex.	Brightest or Best Defined Border.	Width of Base.	Distance of Apex from Sun.	
1896.		h m °			°	
Nov. 14	4.15 A.M.	π Leonis		10°	85	Morning observation. Spica lies much nearer S. edge of base than N.
1897.						
Nov. 13	7.30 P.M.			Indefinite		Traced Band right across sky, apparently nearly coincident with ecliptic. Base very indefinite.
23	7.0			Behind a cloud	80	Axis about coincident with ecliptic at δ Capricorni. From this onwards across sky Band was about 5° broad, and seemed north of ecliptic, as β Arietis touched its N. edge. It passed about midway between Pleiades and Aldebaran.
Dec. 14	7.30	ζ Tauri		About 20°	105	Base very diffused. Band right across sky, about on the ecliptic.
1898.						
April 15	8.0	ζ Tauri		Very indefinite	55	Pleiades in centre of base. Air seems thick. Band not seen. Light very indefinite.
16	8.30	Milky Way				Band traced right across sky, about 5° or more broad. Passed between κ and δ Geminorum, crossed δ Cancri, 31 Leonis, θ Virginis, between ι and κ Virginis, and between α and β Libræ. Band had no defined edges, and when I swept over it rapidly I thought I could trace it out to 10° broad. Western horizon glowing with diffused, indefinite light.

Funchal, Madeira:
1898 *April* 18.

PHILOSOPHICAL

The Markings on Venus. By A. E. Douglass, A.B.

(*Communicated by the Secretaries.*)

The reading public has been recently addressed on the subject of the markings on *Venus* in various attempts to show that the discoveries made at this observatory are unworthy of credit. No matter how futile such criticism must prove to be in the long run, some persons will be influenced by it if we do not from time to time make some rejoinder, or give out some statement which will show our continued activity in this line of work, our undiminished confidence in the results obtained, and our answering attitude towards adverse opinion.

In the last six years many thousands of hours have been spent by us at telescopes of 13, 18, and 24 inches aperture and their smaller finders, when the seeing was sufficiently good for profitable work on the finest known planetary detail. Expressed in standard terms, the seeing was practically always such that in a 6-inch aperture the spurious disc of the interference pattern was well defined, and a very large part of the time the rings of the same pattern were unbroken. I consider that any astronomer who cannot say the same for the seeing during his hours of work, and whose hours of work do not reach a commendable number, has no right to criticise our results; for he lacks the experience by which alone he becomes capable of judging.

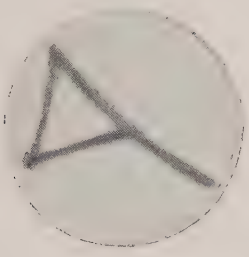
Under proper conditions of air and aperture the markings on *Venus* are absolutely certain. Under proper conditions they are to me about as easy or difficult to see as the irregularities on the terminator of the Moon when it is near the first quarter, viewed by the naked eye. I have on a few occasions seen a large projection perfectly distinct. So it is with *Venus*. At the best seeing the markings are visible at the first glance.

To say that no markings save M. Antoniadi's symmetrical shadings of atmospheric contrast exist, or that the detail seen here is due to pressure on our objective, or to defective densities in the eye-piece, or to our own eyes, or to the imaginings of our brains; or, most ridiculous of all, to our looking all day at some map and then seeing it on the planet, is to offer suggestions too absurd to be taken seriously.

We use the telescope in both positions, normal and reversed: that shows that the markings are not in the lens. We use different eye-pieces and twist them in varying position angles: that shows that the markings are not there. We sit in different positions, so the markings cannot be in our eyes; and different persons in perfect independence find the same detail, so it is not a mental phenomenon.

In order to test our results in a formal manner, I made the following experiments on the afternoon of April 19, when the

1



Detail seen in each combination of aperture and focus, save one, 1898 April 19

2

Detail drawn 1898 April 19 10^h 47^m G. M. T

3

Mr. Drew's drawing of 1898 April 19, 13^h 5^m

VENUS.—Lowell Observatory, Flagstaff, Arizona

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seeing was very good. To improve the comparison a power of about 150 was used in every case; the detail visible and unchanged in a single essential throughout is shown in the accompanying drawing (plate 5). It is not symmetrical with respect to its centre, and therefore a reversal of it would have shown at once. In every test a complete observation was made, and in all save the first the detail was seen with absolute certainty.

Aperture. in.	Focal Length. in.	Position of Tube.	Remarks.
24	372	E. of pier	No detail; planet too bright and badly "shattered" by air currents.
3+	372	E. „	Detail perfectly evident. This aperture was obtained by a small diaphragm over the eye-piece.
3	372	E. „	Detail perfectly evident; diaphragm over objective.
3	372	E. „	Twisting eye-piece or changing position angle of eyes makes no difference.
3	372	W. „	Detail perfectly evident, and exactly the same.
1·6	372	E. „	Detail evident, not quite so well defined. Planet pure white, no diffraction ring.
4	59	E. „	Detail evident, seeing not quite so good as in 3-inch aperture.
3	59	E. „	Detail exactly the same as in long focus or better, as Sun does not shine on end of tube.
1·6	19·5	E. „	Detail the same, but not so well defined, planet yellow, diffraction ring shows.

More than twenty-four hours after making my drawings I saw Mr. Drew's drawings of the same date, and so far as mine went they coincided precisely with his in every detail. I had not seen Mr. Drew's sketches before—in fact those of April 19 were the only ones made by him since the last superior conjunction. On the other hand, I had seen Mr. Drew's drawings of last summer, when *Venus* was on the other side of the Sun, and showed entirely different markings. I had never closely studied Mr. Lowell's map—merely glanced at it casually—and at this time had not seen it in many months; and though I knew it resembled the hub and spokes of a wheel, I did not know what position the centre held with respect to the phase, and in these observations had no idea where the centre ought to be in order to give even a remote resemblance to Mr. Lowell's work.

A final bit of intrinsic evidence is the fact that I saw these lines a little broader and less well defined than Mr. Lowell represents them; that is the difference between us in our drawings of the canals of *Mars*. The difference is, I think, due to our

individual use of the telescope ; for he habitually used on *Mars* a lower power, and on *Venus* a larger aperture, than I did, either one of which would tend to show the lines narrower.

When a man has had a large experience under particularly favourable circumstances, like Mr. Lowell, his report is not lightly to be set aside ; and when he is almost the only one who has experienced these especially favourable conditions, an attempt by another who has never had that experience to prove his results illusions is likely in the end to bring down ridicule on its author.

The first reason why other observers have not seen these markings is bad atmosphere. When I began observing the third satellite of *Jupiter*, for days, even weeks, I drew nothing but hazy indefinite markings or belts, such things as M. Antoniadi describes as appearing to him on *Venus*. But one night after making several drawings of that character the seeing suddenly became superb, the curtain rose as it were, and I saw sharp distinct black lines about which uncertainty was impossible. The very same thing happened on the fourth satellite four days later. I had been drawing the same indefinable shadings, when one night the seeing improved, the curtain again rose, and I perceived sharp definite lines. After once thoroughly understanding the character of the object sought, I could see them and profitably study them under conditions of seeing formerly prohibitory.

The experience on *Venus* has been similar. On the day succeeding my first good view, I spent nearly the whole afternoon without catching a single certain glimpse. Suddenly the seeing improved for an instant, and I saw the same markings unmistakably. If it had not been for that glimpse I would have gone away perfectly ready to believe that no markings existed. I am not surprised that other astronomers doubt them.

The second reason why some other observers have not seen them has been the fault of using too large an aperture. Six years ago I discovered "air waves," and over four years ago I explained theoretically why reducing the aperture is often beneficial. All this has been published in full elsewhere (*Am. Met. Jour.* 1895 and *Pop. Ast.* 1897). I decided long since that in planetary work the greatest efficiency is obtained with the smallest aperture which supplies the required illumination. There is a limit to this, however. An inch and a half lens shows the markings on *Venus* nicely, but they are not so well defined as in a lens of three inches, which in our atmosphere is a very satisfactory size to use. When the seeing is very bad an aperture of less than three inches will become necessary.

A third cause of failure is the effect of heating of the lens and tube by the Sun's rays. For this reason I have found it sometimes advantageous to use the small finder, which is far within the dome and well shaded.

A fourth cause comes from the air within the dome being colder than that without. This is likely to harm the seeing. If

the interior is warmer than the exterior, it will certainly harm the seeing. In fact my latest experiments show that any dome at all is harmful. A sunshade surrounding the tube would be better both night and day.

A fifth cause of failure, and by no means the least important, is the lack of continuity of observations and the lack of a first good view. By the first I mean fair or good observations made many days in succession. For instance if the seeing is only fair it requires the work of several nights in succession, without intervals, to identify with certainty the longitude presented by a satellite of *Jupiter*. By a "first good view" I mean the necessity of one first-class observation before one understands what is sought. After that view the observer can obtain valuable results under conditions in which formerly he failed completely from ignorance of what he was after. It is the same in observing the *Gegenschein*. I have taught many persons to observe it, and I find that teaching consists in getting them to see it well once. After that they can be trusted to pick it out with very small liability to error. This, of course, is most true in atmospheres unclouded by smoke and unlighted by electricity.

No matter how difficult to obtain, a just hearing is our right. No one is entitled to cry out against us until he can show that his atmosphere is approximately as good as the one through which Mr. Lowell discovered these markings. Let our dubious friends, who attempt to show that we as well as they are deluded, devote a portion of their valuable time to work at the telescope under better atmospheric conditions, and no one will misunderstand the silence which will follow.

Lowell Observatory, Flagstaff, Arizona:
1898 *April* 26.

Micrometrical Measures of the Double Stars β 883, *Sirius and Procyon.* By T. J. J. See, A.M., Ph.D. (Berlin).

During the past season we have kept watch on the movements of β 883, and have taken occasion to measure the systems of *Sirius* and *Procyon*, which require very steady definition and of course a powerful telescope. When we first examined β 883 in 1897 August it was evident that no great change had taken place since our last measures in Mexico, and our subsequent observations confirm the slow motion of the companion during the past year. We have just measured these systems, and as they will soon disappear in the west, I submit at this time the results at which we have arrived. Each measure is the mean of three settings of the micrometer.

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β 883.

t	θ_o	ρ_o	Remarks.
		"	
1897·622	38·6	0·25	Closer than at Mexico.
1897·832	36·1	0·36	Clearly divided with black line between components; power 1,500, and great care for angle in last measure.
·832	37·5	0·34	
·832	39·4	0·33	
1898·263	42·3	0·29	Excellent conditions.
·263	42·3	0·23	
·263	45·4	0·27	
·263	43·2	0·27	
1897·622	37·9	0·28	Cogshall.
1897·832	45·7	0·31	Boothroyd.
1898·263	42·9	0·31	,,

These measures show that the angle has not changed more than 6° or 8° during the past year, and it appears that the distance is nearly constant. As the system from 1894 to 1895 moved over an arc of something like 25°, the present result would indicate a longer radius vector, which is also apparent in the measures of distance; the provisional orbit published in *Monthly Notices*, 1897 May is thus in accord with these observations; but at least another year must pass before we can form a trustworthy conclusion as to the character of the orbit. These results, however, distinctly indicate great elongation of the apparent orbit in the parts of the first quadrant now being described. The star separates with a power of only 500 on the 24-inch refractor, and is thus easily measured. In about another year I suspect that the distance will be greatly diminished, and then the angular motion will become very rapid.

Sirius = *A. G. C.* 1.

Besides the measures published in *Astronomical Journal*, No. 418, the following have just been secured :—

t	θ_o	ρ_o	Remarks.
		"	
1898·263	169·6	4·84	Companion fairly distinct, but a little obscured by the rays of the large star.
·263	167·2	4·43	
·263	169·1	4·50	
·263	168·6	5·02	
1898·269	170·1	5·06	
·269	167·2	4·84	
1898·296	169·6	4·71	
·296	170·0	4·76	
1898·273	168·9	4·79	
1898·263	169·1	4·36	Boothroyd.
·269	170·9	4·97	,,
·296	172·2	5·26	,,
1898·273	170·7	4·86	

The motion appears to accord almost perfectly with the orbit given in the *Researches on the Evolution of the Stellar Systems*, vol. i. p. 84, and it is hardly likely that the companion will ever deviate materially from the path there given.

Procyon = Bessel-Schaeberle 1.

t	θ_o	ρ_o	Remarks.
1897·829	329·4	4″·80	About as difficult as companion of Sirius.
1898·263	326·6	4·36	
·263	326·0	4·41	
1898·296	324·6	4·68	Beautifully separated for some moments, companion distinctly purple.
·296	327·3	4·62	
1898·189	326·6	4·57	
1897·829	328·6	4·82	Boothroyd.
1898·263	324·0	4·48	„
1898·296	328·5	5·04	„
1898·129	327·0	4·78	

The first of these measures was made in the autumn just before we issued the catalogue of new stars, and is therefore appended to the measures of known stars communicated to the *Astronomische Nachrichten.*

The measures on the last night (April 19) were extremely satisfactory, and unquestionably indicate orbital motion since Schaeberle's discovery a year and a half ago. As the companion is distinctly purple, the appearance of the system would indicate physical connection. There can no longer be any doubt, I think, that this is the perturbing body suspected by Bessel from irregularities in the proper motion of the bright star. A refined investigation of all the meridian observations of the past fifty years, or a revision and extension of the work of Auwers in connection with recent micrometer measures, would be highly interesting. The present results, combined with Professor Schaeberle's early measures, indicate an annual motion of nearly 6°. This object, like the companion of *η Centauri*=λ_1 207, is easy when the seeing is very steady, but at other times is hopelessly lost in the rays of the large star. The companion is of about 13th magnitude, and would offer no particular difficulty save for its closeness to *Procyon.*

Lowell Observatory, Flagstaff, Arizona:
1898 *April* 22.

The Relative Motion of the Components of γ Leonis. By S. W. Burnham.

As a double star this is one of the most brilliant objects in the heavens, and, as it is within the reach of the smallest telescopes, it has received the attention of all the leading observers

in the last hundred years. It was discovered, or first recorded as a double star, by Herschel I. in 1782, who observed it long enough to recognise the change in the direction of the smaller star. In 1824 Herschel II. said, "There can be no doubt of the motion of γ *Leonis*, though it is probably less rapid than supposed by Sir W. Herschel." From that time it was generally regarded as a binary system, although the relative change was very slow, and the character of it necessarily doubtful. The entire angular motion between 1782 and 1895 is only about 30°, and since the first reliable measures of distance the change to this time is only 12°.

Notwithstanding these unfavourable conditions, attempts have been made to show not only that this is a binary, but to determine the period, and other elements of the orbit. From the measures down to 1845 Hind computed an orbit by the graphical method of Herschel, and found a period of 296 years (*Monthly Notices*, vol. vii. p. 96). As to the value of any such investigation it is only necessary to say that between 1845 and 1830, the date of the first measures which could be of any material use in such an investigation, the companion star had moved less than 5°. Of course the angles of Herschel would be useful if supplemented by complete measures covering an arc of sufficient length to clearly define the apparent path of the companion, but the character of the movement, to say nothing of the exact details of the supposed orbit, could not have been more absolutely unknown in 1845 if the star had never been measured at all.

Since that time another orbit has been computed by Doberck, using the measures down to 1875 (*Trans. R.I. Acad.* vol. xxv.; *Monthly Notices*, vol. xxxv. p. 397; *A.N.* 3448). He found a period of 402·62 years. Between this date and the first measures of Struve the angular motion was less than 10°. Obviously the problem was as indeterminate as ever so far as any particular form of orbit was concerned, even if it were conceded that it was a binary system.

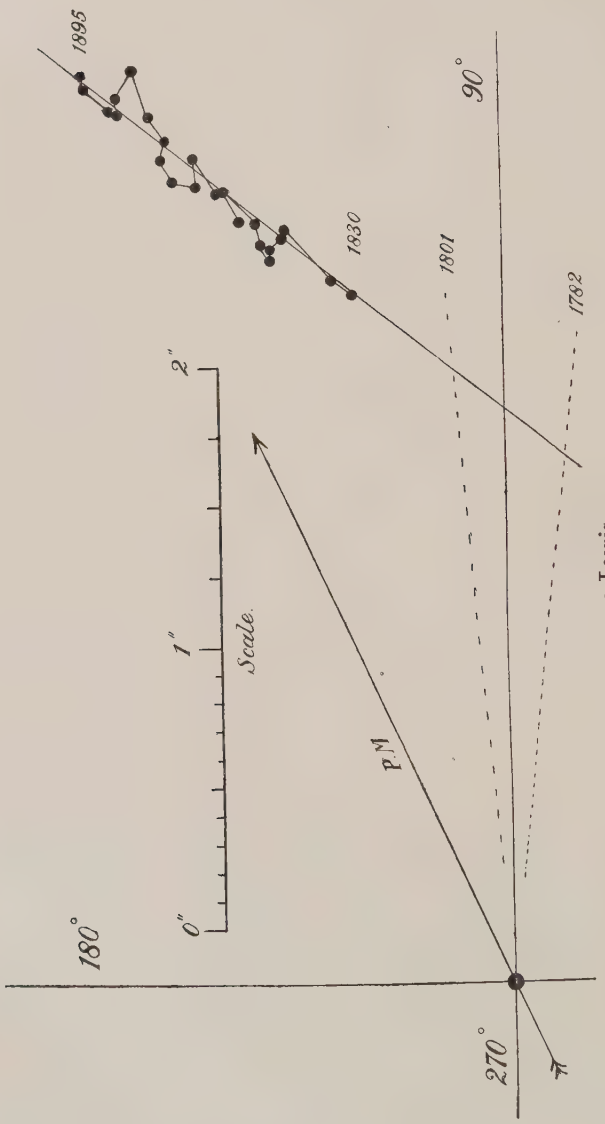
Some time since I laid down to scale some of the principal measures in the last sixty years, and called attention to what seemed to be an obvious fact that the components of γ *Leonis* were probably moving in space with nearly the same proper motion, and in nearly the same direction, like the components of 61 *Cygni* and many other pairs of that type, and showing that at all events the relative change established by the measures was perfectly accounted for by the theory of rectilinear motion. The interest of the subject, especially in view of the fact that the binary character of this pair is still insisted upon, may warrant a more thorough and complete investigation of the observations upon which the orbits referred to have been based, and the measures more recently made; and I have therefore brought together the observations of the best observers during the entire period. They are given in the following table:—

Measures of γ Leonis.

1782·71	83°·5	″ ...	H 2
1801·72	94·8	...	H 7
1830·38	102·4	2·52	Bes 9; Σ 11; Da 8
1833·35	103·7	2·59	Σ 10; Da 11
1840·70	106·1	2·81	OΣ 11; Ma 7; Da 5
1843·09	106·5	2·78	Da 4; Ma 14
1846·56	107·5	2·76	OΣ 12; Ma 5
1847·87	107·8	2·72	Ma 17; Da 7
1851·07	108·1	2·78	OΣ 6; Ma 16; Da 2
1853·40	108·0	2·86	Ma 46; Wr 2; Da 3
1855·30	109·3	3·01	Wn 3; Δ 16; Se 4; Wr 3
1857·51	109·0	2·89	Ma 29; OΣ 5
1860·71	109·8	3·01	Ma 9; Wr 2; Da 7; OΣ 5; Δ 12
1865·31	110·5	3·16	En 17; Se 3; Da 2; Kn 3
1868·33	111·0	3·06	Δ 9; Du 11; OΣ 3
1871·61	112·3	3·11	Δ 12; Du 20; OΣ 3; Kn 3
1875·05	112·5	3·20	Sp 12; Du 9; OΣ 2
1877·05	111·7	3·26	Δ 9; Sp 7
1878·92	112·1	3·36	Hl 10; Sp 9; OΣ 3
1880·83	112·0	3·54	Franz 4; Big 5; Sp 5
1882·88	113·5	3·47	Sp 15; Küstner 7; En 5
1884·86	113·8	3·42	Sp 18; Hl 7; En 6; Per 5; T 3
1888·56	114·2	3·44	Sp 22; B 3; Maw 3; OΣ 2
1892·32	115·0	3·55	Big 10; Lewis 4; Com 6; Lv and J 6; Glase 2; Ho 3
1895·44	114·8	3·60	Com 9; Collins 3; Scott 5; Lewis 3; Glase 2

These positions represent altogether measures on 621 nights, and each angle and distance given is, on the average, derived from measures on 27 nights. Certainly nothing in the way of micrometrical measures could be expected to give any more reliable results when the observers and the number of measures are considered. It will be remembered that this is one of the easiest stars to measure in the heavens, and no more accordant results can be looked for with present instruments and methods of observing.

These measures, and the two angles of Herschel in 1782 and 1801, are shown to scale on the accompanying diagram. It is obvious from inspection that the relative movement of the companion is sensibly rectilinear, and that all the measures are represented with substantial accuracy by the theory of rectilinear


1895
1830
1801
1782
90°
180°
270°
0″
1″
2″
Scale.
P.M.
γ Leonis.

motion. This is shown by the diagram better than it could be by any tabulated results. The annual apparent motion of the companion, derived from all the measures between 1830 and 1895, is found to be 0″·0192 in the direction of 141°·7. The corrections to be applied to the measures are shown in the following table :—

1782·71	+1°·5	(1″·94)	2*n*	1865·31	+0°·3	−0″·04	25*n*
1801·72	−0·8	(2·16)	7*n*	1868·33	+0·3	+0·11	23*n*
1830·38	+0·7	+0·05	28*n*	1871·61	−0·4	+0·11	38*n*
1833·35	+0·2	+0·02	21*n*	1875·05	0·0	+0·08	23*n*
1840·70	−0·4	−0·09	23*n*	1877·05	+1·1	+0·06	16*n*
1842·09	−0·2	−0·02	18*n*	1878·92	+1·0	−0·01	22*n*
1846·56	−0·4	+0·06	17*n*	1880·83	+1·4	−0·16	14*n*
1847·87	−0·5	+0·12	24*n*	1882·88	+0·2	−0·05	28*n*
1851·07	−0·1	+0·11	24*n*	1884·86	+0·2	+0·03	39*n*
1853·40	+0·5	+0·07	51*n*	1883·56	+0·3	+0·08	30*n*
1855·30	−0·4	−0·04	26*n*	1892·32	+0·1	−0·01	31*n*
1857·51	+0·3	+0·10	34*n*	1895·44	+0·7	+0·03	22*n*
1860·71	+0·2	+0·03	35*n*				

It is hardly necessary to say that these computed deviations are less in both angle and distance than the probable errors in the results obtained by the best observers with the best modern instrumental appliances ; that is, no observer could expect any closer agreement by a repetition of his measures.

Upon this theory of motion the following ephemeris is based :

1898·5	115°·9	3″·68
1902·5	116·4	3·75
1906·5	116·9	3·82
1910·5	117·4	3·98
1914·5	117·8	3·96

The principal star of *γ Leonis* has a well-determined proper motion. The meridian observations are ample for the purpose, and there is every reason to believe that the movement so found is as accurate as the recognised proper motion of any other prominent star. From this motion the real movement of the companion star is readily deduced. Taking Auwers' value for the motion of the brighter star, we have for the proper motions of the two stars

A = 0″·323 in the direction of 114°·9

B = 0·340 „ „ 116·4

The ninth magnitude star W[1] x. 234, about 4′ distant in the direction of 290°, has a still larger proper motion, but in nearly the opposite direction. Porter gives this movement from meridian observations as 0″·495 in 270°·9. The micrometrical measures of this star from γ *Leonis* by OΣ give substantially the same value.

Yerkes Observatory:
April 26.

Photographs of the Nebulæ in the Pleiades, of Stars in the Surrounding Regions and of Spurious Nebulosity. By Isaac Roberts, D.Sc., F.R.S.

The photographs annexed are prints from the original negatives, which were taken with the 20-inch reflector and the Cooke 5-inch lens respectively, the exposures of the plates being simultaneous during ten hours. 1st, on 1897 December 22, during $3^h\ 20^m$; 2nd, on the 23rd, during $3^h\ 0^m$; 3rd, on the 25th, during $3^h\ 40^m$—three exposures during an interval of four days. The sky on each occasion was very clear.

Scale of the reflector photograph, 1 millimetre to 81·45 secs. of arc.
Scale of the lens photograph, 1 millimetre to 415 secs. of arc.

On examination of the reflector photo-negative, it is seen that the *Merope* nebula extends from that star to the distance of about 40 minutes of arc, and faintly covers an area of about the same width, in the *south*, *south preceding*, and *south following* directions; the *Maia* nebulosity also extends about 40 minutes of arc in the *nf* direction. The other stars and the nebulosities, which together form the group of the *Pleiades*, and were depicted on my photograph of 1888 December 8, are shown with but little further extensions or obvious changes of form during the nine years' interval, though the density is greater on the present one owing to the longer exposure.

The photograph taken with the 5-inch lens covers an area of the sky measuring about 17° by 17°, of which a little over 10° by 10° are shown annexed, with *Alcyone* in the centre, and it will be observed that the group of the *Pleiades* is completely obscured by the photographic effects of atmospheric glare, to which reference will be made further on. All the stars brighter than the 11th magnitude are, on the negative, visible through the glare; but the fainter stars, together with the known real nebulosities, are entirely obliterated because their light is feebler than that of the glare itself.

Other photographs of this group and of the surrounding regions were also taken with the 20-inch reflector, and simultane-

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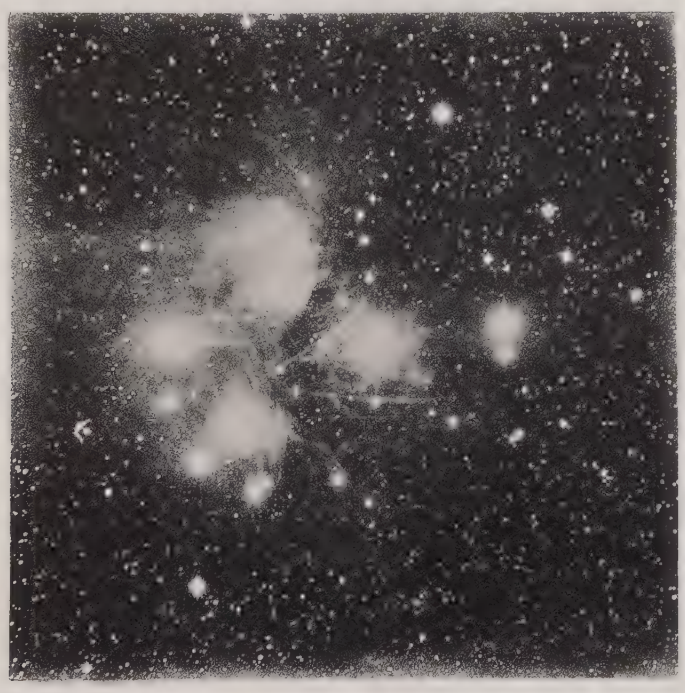
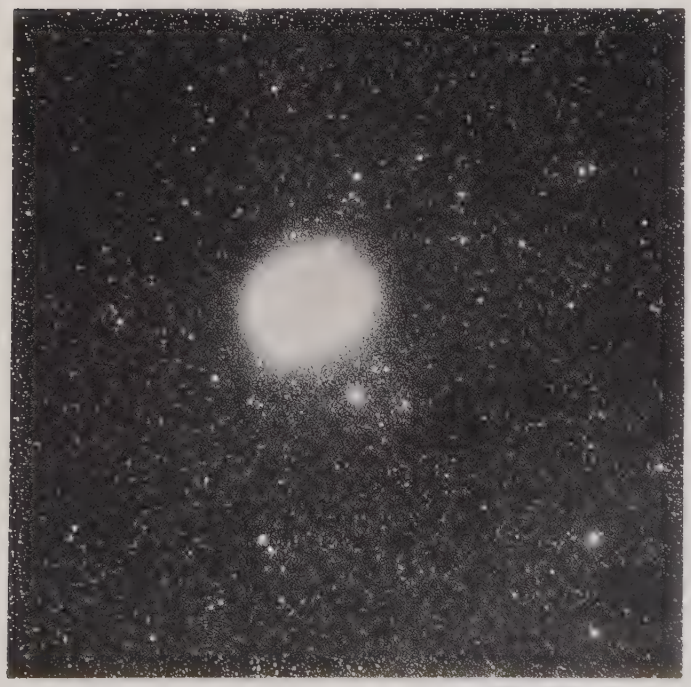
PHOTOGRAPH OF THE PLEIADES

20 in. Reflector—Exposure 10 h.

1



2



PHOTOGRAPH OF THE PLEIADES

5 In. Lens—Exposure 10 h.

PHILOSOPHICAL
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ously with the 5-inch lens, on 1897 October 28, with an exposure of the plate during eight hours, and on 1897 November 19 to 22, with aggregate exposures of the plate during $9^h\ 2^m$. Besides these, several photographs with exposures of the plates during intervals varying between one minute and four hours respectively have been taken during the past ten years.

The descriptive matter following relates to the reflector-photograph annexed hereto, and shown on the screen, as well as to the other two with long exposures, referred to above.

The nebula round *Merope* is of a streaky character, with the star in the centre of the denser part : the streaks trend in *south following* to *north preceding* directions for a distance of about 16 minutes of arc, and then curve in the direction *south preceding*, where the nebulosity becomes very faint but still streaky in character, and spreads out to the extent of 50 minutes of arc in breadth. It does not seem to commingle in any degree with the other adjacent nebulosities, and there are four faint stars involved in it within a distance of 60 seconds of arc from *Merope*. Besides these, there are other bright and faint stars involved in the nebulosity.

A straight streak of dense nebulosity extends across the two stars 1 and 7 (*Bessel*) : it is about 19 minutes of arc in length, and does not seem to form a part of any of the other nebulosities. I infer that it is an independent nebula seen edgewise, and there is a bright star at its centre and three faint stars apparently involved.

Electra does not seem to be involved in nebulosity, but there is a streak of strong nebulosity extending to a distance of about 14 minutes of arc from it towards the *following* direction, and it is divided along its full length into two equal parts by a faint dark streak. Six stars of between 13th and 16th magnitudes are apparently involved in this nebula, which is seen edgewise, and is, I think, independent of the others. The nebulosity which extends from *Maia* crosses the streak above referred to at an angle of 45°, but no physical result seems to have been caused by this, which confirms the idea of the separate existence of both nebulæ.

Alcyone is surrounded by nebulosity of both a streaky and flocculent character. The streaks on the *following* side trend *south following* to *north preceding*, and those on the *preceding* side cross the streaks of the *Maia* nebula at nearly right angles, without appearance of either disturbance or of commingling. This again points to the nebulæ being independent. To the north of *Alcyone* is a streak of nebulosity 30 minutes of arc in length, slightly curved towards the north, and involves the stars 10 and 24 (*Bessel*), besides twelve other stars of between 12th and 18th magnitudes. This appears to be an independent nebula seen edgewise, and is probably of a spiral character. The north part of the *Alcyone* nebula seems to cross this streak without causing any disturbance to either of them.

Maia is surrounded by streaky nebulosity trending north and south in parts, and *north following* to *south preceding* in other parts. To the *north following* it extends in a long streaky arm a little beyond the star 12 (*Bessel*)—a distance of about 44 minutes of arc, and on the *north preceding* side reaches *Taygeta*. There is also evidence of very faint nebulosity extending 30 minutes of arc on the *south following* side towards *Maia*.

No clear proof is given that *Pleione* and *Atlas* are involved in nebulosity.

It appears to me that the evidence, taken as a whole, points strongly to the probability that the *Pleiades* consist of a group of stars seen by us either behind or else in front of a group of nebulæ, *Alcyone*, *Merope*, and *Maia* being involved in nebulosity; but at present there is no indication of physical connection between the other nebulæ and these three, or with each other. I may further add that it will be an exceedingly difficult work to extend materially the knowledge we now possess concerning the group until movements, and changes of structure, can be detected amongst its components.

I shall here draw attention to a paper by Professor Barnard, published in the *Monthly Notices* of this society, vol. lvii. pp. 10–16. On p. 14 he states: "At a meeting of the B.A.A. on April 29 Dr. Roberts took a further opportunity to object to these star pictures, and is reported to have said the exterior nebulosities shown on my *Pleiades* photographs were not nebulosity, and he made the assertion without fear of anyone proving the contrary. . . . That these nebulosities exist as shown on my photographs there can be no doubt whatever."

A copy of the photograph referred to and also a diagram-sketch are appended to his paper; and his photo-copy of the original negative is placed in the archives of the Society, and will now be shown on the screen. Those who will take the trouble to examine these photographs will be struck with the very coarse character of the film; with the distorted images of the stars; with the halation circles round the brighter stars, caused by the omission of backing the plate; and with the large patch of something (stated to be nebulosity) covering the group of the *Pleiades*; and it is upon this one defective photograph that Professor Barnard bases his unqualified assertion that there is no doubt whatever that these nebulosities exist as shown on his photograph. The vague suggestion of visibility in a telescope is quite inadmissible so long as the bright nebulosities known to exist in the group cannot be seen.

The six photographs (three with the reflector and three with the 5-inch lens) which have been taken at my observatory between 1897 October 28 and December 1—a copy of the latter being hereto annexed—entirely discredit the existence of Professor Barnard's nebulosity. These photographs were taken with proper care; the star images are not distorted; there is no halation effect; the sky was clear during the various exposures of the

plates, and the exposures were equal as regards photographic effect, for the stars and nebulosities shown on the plate with 10 hours are also shown on the $9^h\ 2^m$ and on that with 8 hours' exposure.

I must further remark on Professor Barnard's paper that in it he misquotes from my work—misconstrues my statements—gives measurements of the distances of certain nebulæ, on two of his photographs, which are in error to the extent of so much as $2\frac{1}{2}$ degrees in 8 degrees on one, and 53 minutes in 4 degrees on the other; counts stars on a plate I have never seen, and of which I know nothing, then by this insinuates that my count of the stars on another plate, which he sent to this Society, cannot be correct; states that I have distinctly denied the existence of nebulosity in certain parts of the sky, whereas the reverse of this is true—for I have shown and published not only the existence but also the structural details of the nebulosity. This list does not exhaust the statements contained in the paper that require correction.

When very sensitive gelatine plates have been exposed to the sky during several hours they are liable to show, after development, dark patches of unequal density on various parts of the films, the light and dark parts presenting the appearance of nebulosity. These appearances may be caused by imperfections in the lenses used; by coarseness of grain and irregularities in the films; by insufficient cleaning or of smears on the plates; by slowly passing clouds during the exposures, or by omission of simultaneously flooding the films in developing the plates. The appearances may also be intensified by moonlight, or by omitting to back the plates, with a non-reflecting material, to prevent the effects of reflections of starlight (halation) from the back of the negatives. In making positive, or contact, copies of such negatives the film defects referred to are greatly intensified, and during the correlative operations the appearances of spurious nebulosity are also intensified.

Besides these mechanical defects there is the physical cause, due to illumination by starlight of the Earth's atmosphere, which affects the sensitive films during long exposures of the plates. This produces those appearances of spurious nebulosity in which the stars in the Milky Way seem to be immersed, and is one of the chief causes that mislead the inexperienced in stellar photography.

The scale of the photographs taken with portrait lenses of 6 inches aperture and under being small, and the photo-images of the bright stars relatively large, the stars down to the 4th or 5th magnitude to which the photo-plates have been exposed during intervals of from 4 to 10 hours have their photo-images involved in circles of apparent dense nebulosity—and all forms of instruments show these effects—which in reality are due to the atmospheric illumination by the light of the stars and to

diffraction. A similar effect is often visible to sight round the Sun, Moon, and bright stars.

The bright stars which form the group of the *Pleiades* when photographed on the small scale of portrait-lens pictures with exposures of the plates during eight or ten hours will, after development, appear as black spots in the midst of atmospheric glare, and not a trace of the real nebulosities, known to exist in the group, can be detected upon them. Thus also in the case of those vast areas of bright and faint stars in the Milky Way, and in other crowded star areas, when they are photographed on the small scale of portrait-lenses, have their aggregate light, which illuminates the Earth's atmosphere over the area photographed, concentrated by the lens upon the photo-film, and thus producing the appearance of the stars being immersed in nebulosity. The contiguous areas in the sky, that are in the field of the lens and have few stars upon them, add to the illusion of nebulosity by causing structural features in the atmospheric glare.

The diffused starlight of the sky, even on dark clear nights, has a powerful effect upon very sensitive photo-films, and I have made several experiments in order to enable me to judge its relative intensity during long exposures of the plates simultaneously in the reflector, in the 5-inch lens camera, and inside a blackened box 6 inches square by 12 inches in height with the open end pointed to the zenith. Parts of the plates in the box were exposed to the sky uncovered, whilst other parts were covered with black paper or with rectangular pieces of polished plate-glass of various thicknesses between 5·63 and 45 millimetres. Exposures were also made under sensitometer scales. By combinations of these methods I have been enabled to estimate the photographic effects of the atmospheric glare upon sensitive films exposed simultaneously in the 20-inch reflector, the 5-inch lens, and to the open sky, under precisely similar conditions as to quality of the sky, duration of exposure, equality in the sensitiveness of the plates, and similarity in the development.

The results showed that the uncovered parts of the films placed in the box were darkened by the sky glare to about the density of the photo-images of stars of the 16th magnitude as they appear after exposures of two and a half hours in the 20-inch reflector, whilst the parts covered with black paper were unaffected, and after development the films were as clear as the glass plates. The parts of the films that were covered with plate-glass had gradations in the photo-density proportional to the absorption and reflection from the surfaces of the light by the respective thicknesses of the plates of glass.

The bearings of these results upon stellar photographs by assisting in the production of appearances of spurious nebulosity are obvious; and it is to the causes referred to in the foregoing paragraphs that the erroneous ideas of the existence of enormous fields of nebulosity in and about the Milky Way have been generated.

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Where real nebulosity exists it is confined to areas relatively small, seldom exceeding two or three degrees in extent.

The evidence now laid before us may be applied to the interpretation of the large areas of so-called nebulosity shown on many photographs that have been presented to the Society or published in *Knowledge* and in other serials.

Referring again to the six photographs of the *Pleiades* that were taken with the reflector and the 5-inch lens, with exposures respectively of 8^h, 9^h 2^m, and 10^h, it is found that upon those taken with the 5-inch lens the faint stars which are shown on Professor Barnard's photograph with $10\frac{1}{4}$ hours' exposure are also shown, but no trace whatever is there of what he designates as the distant nebulosity. But on the photographs taken simultaneously with them by the 20-inch reflector there is much spurious nebulosity visible ; and that it is spurious, and not real, is proved by the fact that, though it appears on each of the three photographs, it does not coincide, either in density, or in position, or in extent, on any of the plates. This could not happen if it were due to real nebulosity, or to concentrated starlight, or even to defects in the lenses ; it must be due to chemical and to atmospheric causes, for otherwise the photo-effects would be alike on each of the plates.

The spurious nebulosity is shown in cloud-like patches, and simulates the real nebulosity so closely that its true character could not be decided, with certainty, without the careful correlation of two or more photographs taken at different times of the same areas in the sky.

A Determination of the Proper Motions of the Greenwich Clock Stars from the Greenwich Transit Circle Observations, 1854–1896. By W. G. Thackeray.

The old Greenwich observations of right ascension are, as is well known, affected by systematic errors due to imperfect clock-star places. To get rid of these errors the places of the clock stars for the last twenty-five years have been specially corrected to the results of the 12-hour groups, with what marked success the 1880 and 1890 catalogues have fully demonstrated. To eliminate these errors in a perfectly orthodox method requires a large amount of honest labour, while the application of arbitrary corrections is not altogether satisfactory. As the Greenwich Transit Circle has been in constant use for nearly half a century, and a considerable number of observations of the clock stars have been made with it during this period on a uniform system, it seemed well worth while to discuss the series of observations with a view to compare the results thus obtained with those derived from much longer and varied series by Professors Auwers and Newcomb.

The right ascensions and north polar distances used in this discussion are those given in the Greenwich 1860, 1864, 1872, 1880 Catalogues, and the results of the ten years' observations 1887–1896 (those not yet published by permission of the Astronomer Royal), modified as fully explained below and reduced to 1890 by the use of the Struve-Peters value of precession, and the proper motions determined by Professor Auwers from Bradley's observations. This system of reduction is generally referred to in this paper as "Auwers'" or "A"; while "Newcomb's" or "N" refers to Professor Newcomb's latest determination of the precession, and proper motions used in his fundamental catalogue for 1900.

Right Ascensions.—The correction for equinox is that determined by a former paper (*Monthly Notices*, vol. lvi. 9) from a discussion of the observations of the Sun made at Greenwich during the years 1836–1895. The actual value of the correction is the difference between the quantity applied in each catalogue and that derived from the formula

$$+0^{s}\cdot015+0^{s}\cdot132\ T,$$

where T is the fraction of a century from the adopted epoch 1880.

The following are the values of these corrections actually adopted :—

	s		s
1860	−0·004	1880	+0·015
1864	+0·008	1887–1896	+0·028
1872	+0·009		

The adopted right ascensions for the years 1887–1896 are the standard right ascensions adopted in the clock-star list for 1896, corrected by $+0^{s}\cdot028$ as above.

The adopted right ascensions for the 1872 and 1880 catalogues are the standard right ascensions given in the introductions to the 1872 and 1880 catalogues.

The adopted right ascensions for the 1860 and 1864 catalogues are the right ascensions given in these catalogues corrected as follows :—The standard right ascensions of the 1872 catalogue were carried back to 1860 and 1864 by means of Struve's precession and the Auwers-Bradley proper motions, and a comparison for each star made between these deduced places and those given in the 1860 and 1864 catalogues. The general mean was then found and taken out, and the resulting corrections were then formed for groups of 1^{h} of R.A., with weights corresponding to the number of observations. These corrections are given under the heading $\delta\alpha_{a}$ in the following table (a similar table will be found on p. 8 of the introduction to the 1872 catalogue, but depending on the proper motions then in use, which have been superseded by those of Auwers). After the applica-

tion of these corrections, δa_α, to the original differences the new quantities were again arranged in groups of 5° of N.P.D. with the same weights, and means formed. These values constitute the corrections depending on N.P.D., and are given under the heading δa_δ in the following table. The extension of a group to more than 5° simply means that the several corrections under each 5° were practically identical. The resultant correction to be applied to the adopted catalogue places will be the algebraic sum of the two corrections, δa_α and δa_δ.

Corrections to the Places of Clock Stars in the Greenwich 1860 *and* 1864 *Catalogues for Periodic Errors depending on Right Ascension and North Polar Distance* (δa_α *and* δa_δ), *combined with Equinox Correction of* −0ˢ·004 *to the* 1860 *Catalogue, and* +0ˢ·008 *to the* 1864 *Catalogue derived from Greenwich* ⊙ *Observations* 1836–95.

R.A.	1860. $\delta a_\alpha - 004$.	1864. $\delta a_\alpha + 008$.	R.A.	1860. $\delta a_\alpha - 004$.	1864. $\delta a_\alpha + 012$.
h	s	s		s	s
0	+0·013	+0·024	12	−0·002	+0·012
1	+ ·011	+ ·018	13	− ·006	+ ·012
2	+ ·004	+ ·012	14	− ·014	+ ·008
3	− ·011	+ ·010	15	− ·015	+ ·007
4	− ·017	+ ·005	16	− ·012	+ ·003
5	− ·019	+ ·002	17	− ·011	+ ·001
6	− ·023	− ·005	18	− ·004	+ ·008
7	− ·026	− ·014	19	+ ·005	+ ·017
8	− ·025	− ·015	20	+ ·014	+ ·019
9	− ·022	− ·008	21	+ ·016	+ ·016
10	− ·016	− ·002	22	+ ·020	+ ·018
11	− ·008	+ ·004	23	+ ·019	+ ·024

1860. N.P.D.	δa_δ	1864. N.P.D.	δa_δ
° °	s	° °	s
50–55	−0·036		
55–60	− ·030	50–65	−0·016
60–65	− ·023		
65–75	− ·006	65–75	− ·005
75–85	+ ·005	75–85	+ ·002
85–95	+ ·008	85–100	+ ·009
95–105	+ ·012	100–110	+ ·002
105–125	+ ·024	110–125	+ ·013

When necessary, the various catalogue places have been further corrected for any difference in the adopted proper motions (Auwers'), and those used in the catalogues.

Procyon has been specially corrected for orbital motion from Auwers' paper (*Ast. Nach.* 1371–2–3).

North Polar Distances.—These observations have been corrected to the following uniform system (*Mem. R.A.S.* vol. xlv.), viz.—Flexure=·00 ; formula for R—D $a+b \sin z$, virtually flexure, Bessel's refractions, and colatitude 38° 31′ 21″·90. This means that the north polar distances of the 1860 and 1864 catalogues have been increased by 0″·10 for colatitude, the value used in the catalogues being 21″·80. The north polar distances of the 1864 and 1872 catalogues have been corrected for R—D by the table given below, and those of 1872 have been further corrected by the table given at the end of the introduction to the 1872 catalogue itself to reduce them to Bessel's refractions and colatitude 21″·90. Like the right ascensions the N.P.D.'s have also been corrected for any differences in the adopted proper motions, and those used in the various catalogues. *Procyon* has also been pecially corrected for orbital motion (see above).

Table of corrections for R—D to reduce the observations 1862–1876 *to the system* $a+b \sin z$.

Year.	60°	70°	80°	90°	100°	110°	120°
	″	″	″	″	″	″	″
1862	·00	−·03	−·11	−·19	−·30	−·37	−·40
3	·00	−·04	−·13	−·23	−·34	−·45	−·48
4	·00	−·02	−·09	−·16	−·24	−·32	−·34
5	·00	−·05	−·14	−·28	−·42	−·55	−·58
6	·00	+·05	+·14	+·29	+·43	+·57	+·60
7	·00	+·04	+·11	+·21	+·32	+·42	+·45
8	·00	+·05	+·17	+·32	+·49	+·64	+·69
9	·00	+·06	+·15	+·29	+·44	+·58	+·63
70	·00	+·04	+·14	+·26	+·39	+·51	+·55
1	·00	+·04	+·14	+·26	+·39	+·51	+·55
2	·00	+·03	+·10	+·19	+·30	+·39	+·42
3	00	+·04	+·11	+·22	+·33	+·43	+·46
4	·00	+·03	+·10	+·19	+·29	+·40	+·42
5	·00	+·02	+·06	+·11	+·18	+·23	+·24
6	·00	+·02	+·07	+·14	+·21	+·27	+·29

From the observations thus corrected and reduced corrections were obtained to the adopted proper motions, as is most easily explained by the following example. Columns (5) and (14) are deduced as follows :—The epoch corresponding to the mean of the group 1887–1896 is regarded as standard, and the number of years elapsed between the epoch and that of any other catalogue is the number of years on which the proper motion depends. In the same way columns (6) and (15) represent the differences of R.A. or N.P.D. between the R.A. and N.P.D. corresponding to the group 1887–1896 regarded as standard and the R.A. and N.P.D. at the other epochs. Columns (7) and (16), the weight, is derived from the expression $\frac{\text{no. of observations} \times \text{years}}{100}$. The remaining columns explain themselves.

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Computation of Corrections to Auwers' Proper Motions.

α Andromedæ

Catalogue.	R.A. 1890.	Adopted P.M. +s·0095 Date. 1800. +	No. of Obs.	No. of Years.	Diff. of R.A.	Wt.	Corrected P.M. +s·0102 No. of Obs. × Years.	Years × Wt.	Diff. of R.A. × Wt.	N.P.D. 1890.	Adopted P.M. +″·156 Date. 1800. +	No. of Obs.	No. of Years.	Diff. of N.P.D.	Wt.	Corrected P.M. +″·150 No. of Obs. × Years.	Years × Wt.	Diff. of N.P.D. × Wt.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
	h m s				s				+ − s s	° ′ ″				″				+ − ″
1860	0 2 42·063	57·8	89	35·4	+·024	21	20·89	743·4	·504	61 31 0·95	58·1	53	34·9	−0·24	18	...	628·2	4·32
1864	·052	64·8	56	28·4	+·035	16	15·92	454·4	·560	0·80	65·2	44	27·8	− ·09	12	...	333·6	1·08
1872	·074	71·7	62	21·5	+·013	13	13·33	279·5	·169	0·76	72·2	64	20·8	− ·05	13	...	270·4	·65
1880	·097	82·1	69	11·1	−·012	8	7·66	88·8	·096	0·86	81·7	42	11·3	− ·15	5	...	56·5	·75
1887–1896	·087	93·2	131					1566·1	1·233	0·71	93·0	100					1288·7	6·80
									·096									
									1·137									

$$\text{Correction} = \frac{+1^{s}\cdot137}{1566\cdot1} = +^{s}\cdot0007$$

$$\text{Correction} = \frac{-6''\cdot80}{1288\cdot7} = -''\cdot006$$

In the following table are given the deduced proper motions from the Greenwich Observations, as well as the corrections to Auwers' and Newcomb's systems of proper motions, where system of proper motion means the combined effect of precession, and what is generally termed proper motion.

Table of Proper Motions of the Greenwich Clock Stars from the Greenwich Transit Circle Observations 1854–1896, *and Corrections to Auwers' and Newcomb's Systems of Proper Motions.*

Star.	Approx. R.A.	Approx. N.P.D.	P.M. Right Ascension. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.	P.M. North Polar Distance. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.
	h m	° ′	s	s	s	″	″	″
α Androm.	0 3	61 31	+·0102	+·0007	−·0002	+0·150	−·006	−·019
γ Pegasi	8	75 26	+·0002	+·0009	+·0002	+ ·009	−·004	−·007
ι Ceti	14	99 26	−·0019	+·0013	−·0003	+ ·047	+·015	+·012
44 Piscium	20	88 40	−·0013	+·0015	+·0005	+ ·028	+·017	−·001
12 Ceti	24	94 34	+·0003	+·0006	−·0006	+ ·018	+·009	+·011
ε Androm.	33	61 17	−·0178	+·0006	−·0002	+ ·237	−·014	−·022
β Ceti	38	108 35	+·0154	+·0007	−·0003	− ·023	+·011	+·012
δ Piscium	43	83 1	+·0055	+·0020	+·0004	+ ·050	+·013	+·001
20 Ceti	47	91 45	+·0006	+·0028	+·0015	+ ·025	+·016	+·017
μ Androm.	51	52 6	+·0115	−·0026	−·0011	− ·034	+·015	−·010
ε Piscium	57	82 42	−·0056	+·0014	+·0002	− ·022	+·017	−·002
β Androm.	1 4	54 58	+·0144	·0000	+·0002	+ ·110	+·026	−·012
ζ^1 Piscium	8	83 0	+·0086	+·0011	−·0006	+ ·065	+·014	+·008
θ Ceti	19	98 45	−·0058	+·0010	+·0002	+ ·231	+·035	+·010
η Piscium	26	75 13	+·0017	+·0019	+·0007	+ ·006	+·003	−·002
ν Piscium	36	85 4	−·0013	+·0021	+·0005	+ ·002	+·007	+·001
ο Piscium	40	81 24	+·0043	+·0014	−·0003	− ·044	+·014	−·004
β Arietis	49	69 44	+·0067	+·0017	+·0007	+ ·105	+·003	−·009
α Arietis	2 1	67 3	+·0141	+·0014	+·0007	+ ·140	+·006	−·008
ξ^1 Ceti	7	81 40	−·0025	+·0007	−·0008	+ ·026	+·025	+·005
67 Ceti	12	96 56	+·0053	+·0017	+·0002	+ ·117	+·008	+·003
ξ^2 Ceti	22	82 2	+·0019	+·0008	−·0002	+ ·008	+·007	−·002
ν Ceti	30	84 53	−·0014	+·0037	+·0014	+ ·019	−·009	−·002
δ Ceti	34	90 9	−·0001	−·0005	−·0008	− ·021	−·028	−·019
γ^2 Ceti	38	87 14	−·0094	+·0020	+·0006	+ ·147	−·009	−·007
σ Arietis	45	75 22	+·0007	+·0009	−·0004	+ ·026	−·013	−·011
ε Arietis	53	69 6	−·0015	+·0010	−·0001	+ ·010	+·004	−·003
α Ceti	57	86 21	−·0005	+·0024	+·0007	+ ·081	+·008	−·002
δ Arietis	3 5	70 41	+·0104	+·0009	−·0001	+ ·005	+·010	+·003
τ^1 Arietis	15	69 15	+·0016	+·0008	−·0002	+ ·018	−·012	−·017
ο Tauri	19	81 22	−·0045	+·0007	+·0006	+ ·097	+·029	+·020

Star.	Approx. R.A.	Approx. N.P.D.	P.M. Right Ascension. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.	P.M. North Polar Distance. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.
	h m	° ′	s	s	s	″	″	″
f Tauri	3 25	77 26	+·0008	+·0010	−·0003	+·012	+·023	+·012
ϵ Eridani	28	99 50	−·0668	+·0007	−·0006	−·023	−·012	+·002
11 Tauri	34	65 2	+·0012	+·0014	+·0003	+·006	−·005	−·005
δ Eridani	38	100 8	−·0079	+·0002	−·0016	−·733	+·010	−·004
η Tauri	41	86 14	+·0017	+·0021	+·0005	+·041	+·001	−·011
γ^1 Eridani	53	103 49	+·0046	+·0017	+·0001	+·113	+·007	+·002
A^1 Tauri	58	68 13	+·0070	+·0017	+·0006	+·052	−·006	−·006
ω^1 Tauri	4 3	70 41	+·0072	+·0011	−·0002	+·032	−·001	−·013
o^1 Eridani	7	97 8	+·0003	+·0009	+·0001	−·090	−·005	−·006
γ Tauri	14	74 38	+·0080	+·0007	+·0002	+·014	−·016	−·013
ϵ Tauri	22	71 4	+·0084	+·0014	+·0008	+·018	−·010	−·016
Aldebaran	30	73 43	+·0052	+·0017	+·0012	+·178	−·006	−·011
τ Tauri	36	67 15	+·0004	+·0014	+·0003	+·025	+·016	+·007
μ Eridani	40	93 27	+·0011	+·0013	+·0002	+·014	+·012	+·004
ι Aurigæ	50	57 1	+·0010	+·0004	+·0001	+·014	+·011	−·006
ϵ Leporis	5 1	112 31	+·0020	+·0016	+·0009	+·042	−·026	−·021
Rigel	9	98 20	+·0007	+·0019	+·0009	−·007	−·002	−·007
β Tauri	19	61 29	+·0027	+·0014	+·0008	+·156	−·024	−·019
δ Orionis	26	90 23	+·0007	+·0021	+·0011	+·005	·000	+·004
α Leporis	28	107 54	−·0009	+·0002	−·0009	·000	+·010	·000
ϵ Orionis	31	91 16	+·0008	+·0026	+·0012	−·005	+·001	−·004
α Columbæ	36	124 8	−·0015	...	+·0021	...	...	...
κ Orionis	43	99 43	+·0009	+·0026	+·0011	+·005	+·009	+·002
α Orionis	49	82 37	+·0020	+·0012	+·0003	−·011	+·013	−·001
1 Geminor.	57	66 44	−·0011	−·0001	−·0008	+·108	+·015	+·002
ν Orionis	6 1	75 13	+·0001	+·0004	−·0007	+·043	+·030	+·021
η Geminor.	8	67 28	−·0057	−·0007	−·0013	+·006	+·003	−·008
μ Geminor.	16	67 26	+·0043	+·0006	+·0003	+·096	−·005	−·014
β Canis Maj.	18	107 54	−·0012	+·0003	−·0003	+·019	+·022	+·025
ν Geminor.	22	69 43	−·0002	+·0020	+·0009	+·011	+·005	−·001
γ Geminor.	31	73 30	+·0038	+·0015	+·0010	+·039	+·004	−·004
ξ Geminor.	39	76 59	−·0086	+·0001	−·0005	+·192	−·003	+·002
θ Canis Maj.	49	101 54	−·0096	+·0009	−·0004	+·033	+·030	+·029
ϵ Canis Maj.	54	118 49	−·0011	·0000	−·0007	−·005	+·012	+·002
ζ Geminor.	58	69 19	−·0016	−·0005	−·0009	−·009	−·008	−·012
γ Canis Maj.	59	105 28	−·0013	+·0005	−·0014	+·023	+·020	+·017
51 Geminor.	7 7	73 39	+·0006	+·0003	−·0009	+·034	+·001	−·004

Star.	Approx. R.A.	Approx. N.P.D.	P.M. Right Ascension. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.	P.M. North Polar Distance. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.
	h m	° ′	s	s	s	″	″	″
δ Geminor.	7 14	67 48	−·0017	+·0008	−·0002	+·008	+·011	−·003
β Canis Min.	21	81 29	−·0039	+·0003	−·0003	+·040	+·010	−·002
Castor	28	57 52	−·0138	+·0013	+·0011	+·089	+·010	+·011
Procyon	34	84 30	−·0464	+·0010	+·0012	+1·037	+·010	+·005
Pollux	39	61 42	−·0464	+·0017	+·0011	+·048	−·003	−·002
ξ Argus	45	114 35	−·0018	−·0007	−·0013	+·018	+·042	+·023
6 Cancri	57	61 54	−·0018	+·0007	−·0003	+·030	−·009	−·017
ρ Argus	8 3	113 59	−·0068	+·0007	−·0002	−·043	+·018	+·014
β Cancri	11	80 28	−·0043	+·0001	−·0004	+·041	·000	−·007
d^1 Cancri	17	71 19	−·0042	+·0011	·0000	+·009	−·013	−·017
η Cancri	26	69 11	−·0030	+·0009	·0000	+·039	−·008	−·011
γ Cancri	37	68 8	−·0078	+·0009	−·0003	+·039	+·006	+·001
ε Hydræ	41	83 11	−·0132	+·0003	−·0001	+·051	+·028	+·007
α Cancri	52	77 43	+·0024	+·0014	+·0003	+·033	+·011	−·002
κ Cancri	9 2	78 53	−·0013	+·0015	+·0003	·000	+·009	−·007
83 Cancri	13	71 50	−·0089	+·0001	−·0010	+·123	−·016	−·007
α Hydræ	22	98 11	−·0016	+·0003	−·0002	−·037	+·015	+·002
ξ Leonis	26	78 13	−·0068	+·0008	−·0002	+·095	+·035	+·017
o Leonis	35	79 36	−·0103	+·0001	−·0005	+·027	+·009	·000
ε Leonis	40	65 43	−·0035	+·0008	+·0003	+·007	−·001	−·009
μ Leonis	47	63 29	−·0168	+·0017	+·0007	+·048	+·003	·000
π Leonis	54	81 26	+·0028	+·0012	+·0005	+·016	+·005	−·004
Regulus	10 3	77 30	−·0166	+·0016	+·0006	−·010	+·008	−·004
γ^1 Leonis	14	69 36	+·0218	+·0010	+·0009	+·134	−·002	−·011
μ Hydræ	21	106 17	−·0103	−·0005	·0000	+·067	+·006	−·007
ρ Leonis	27	80 8	−·0010	+·0002	−·0003	−·002	+·009	+·001
34 Sextantis	37	85 51	−·0065	+·0025	−·0004	−·036	−·003	−·002
l Leonis	43	78 52	−·0008	+·0007	−·0022	+·028	+·008	+·001
d Leonis	55	85 48	+·0006	+·0024	+·0004	−·005	−·017	−·021
χ Leonis	59	82 4	−·0235	+·0020	+·0002	+·034	+·012	·000
δ Leonis	11 8	68 52	+·0099	−·0003	−·0005	+·126	+·011	−·008
δ Crateris	14	104 11	−·0094	+·0012	−·0002	−·197	+·012	+·004
τ Leonis	22	86 32	+·0008	+·0018	+·0003	+·013	+·007	+·003
υ Leonis	31	90 13	−·0003	+·0015	·0000	−·056	−·009	−·011
β Leonis	43	74 49	−·0347	+·0009	−·0002	+·109	+·011	−·003
β Virginis	45	87 37	+·0492	+·0011	+·0002	+·267	+·005	−·002
π Virginis	55	82 46	−·0008	+·0020	+·0004	+·029	+·012	+·003

Star.	Approx. R.A.	Approx. N.P.D.	P.M. Right Ascension. Greenwich	Greenwich minus Auwers.	Greenwich minus Newcomb.	P.M. North Polar Distance. Greenwich	Greenwich minus Auwers.	Greenwich minus Newcomb.
	h m	° ′	s	s	s	″	″	″
o Virginis	11 59	80 59	−·0155	+·0004	−·0004	− ·040	+·009	−·001
ϵ Corvi	12 4	112 0	−·0067	−·0008	−·0012	− ·005	+·016	+·003
η Virginis	14	90 3	−·0045	+·0011	−·0006	+ ·020	−·002	−·002
δ^2 Corvi	24	105 54	−·0161	−·0019	−·0017	+ ·140	−·006	−·002
β Corvi	29	112 47	−·0017	+·0016	−·0006	+ ·057	+·005	+·002
ρ Virginis	36	79 9	+·0047	+·0014	−·0010	+ ·083	−·005	−·018
35 Virginis	42	85 50	−·0010	+·0020	−·0003	+ ·005	−·001	−·001
31 Comæ	46	61 52	−·0020	+·0007	+·0005	+ ·001	−·017	−·017
δ Virginis	50	86 0	−·0320	+·0016	+·0002	+ ·061	+·014	+·006
ϵ Virginis	57	78 27	−·0192	·0000	−·0002	− ·023	+·006	−·002
θ Virginis	13 4	94 57	−·0034	+·0009	·0000	+ ·031	−·006	−·002
Spica	19	100 35	−·0025	+·0019	+·0008	+ ·037	+·019	+·011
ζ Virginis	29	90 2	−·0195	+·0010	+·0003	− ·039	+·017	+·005
m Virginis	36	98 9	−·0076	+·0009	+·0001	− ·036	+·010	+·002
τ Boötis	42	72 0	−·0345	+·0001	−·0001	− ·033	+·007	−·003
η Boötis	49	71 3	−·0049	·0000	−·0003	+ ·354	+·010	−·004
τ Virginis	56	87 55	+·0007	+·0012	·0000	+ ·011	−·022	−·012
94 Virginis	14 0	98 21	−·0002	+·0030	+·0013	− ·022	−·010	−·009
κ Virginis	7	99 46	−·0007	−·0003	−·0009	− ·138	+·003	−·001
Arcturus	11	70 15	−·0781	+·0018	·0000	+ 1·989	+·012	−·011
f Boötis	21	70 17	−·0053	+·0004	·0000	− ·026	+·003	−·006
ρ Boötis	27	59 9	−·0080	+·0005	−·0005	− ·125	·000	−·007
ϵ^2 Boötis	40	62 28	−·0032	+·0011	+·0004	− ·021	−·020	−·007
α Libræ	45	105 35	−·0076	+·0017	+·0007	+ ·071	−·001	·000
ξ^2 Libræ	51	100 58	−·0002	+·0017	+·0008	− ·010	−·004	−·008
ψ Boötis	59	62 37	−·0126	+·0019	+·0008	− ·001	−·009	−·012
ι^1 Libræ	15 6	109 22	−·0030	+·0007	+·0006	+ ·038	−·004	−·012
β Libræ	11	98 59	−·0072	+·0007	−·0002	+ ·020	+·003	−·001
o^2 Libræ	17	104 44	−·0005	+·0020	+·0004	− ·018	−·005	−·012
ζ^1 Libræ	22	106 20	−·0001	+·0009	−·0002	+ ·034	−·012	−·006
α Coronæ	30	62 55	+·0094	+·0009	+·0006	+ ·082	−·012	−·015
α Serpentis	39	83 14	+·0096	+·0017	+·0011	− ·051	+·005	−·006
ϵ Serpentis	45	85 11	+·0089	+·0021	+·0011	− ·059	·000	+·013
γ Serpentis	51	73 59	+·0213	+·0019	+·0004	+ 1·272	−·014	−·015
β^1 Scorpii	59	109 30	−·0023	+·0003	−·0006	+ ·011	−·016	−·014
δ Ophiuchi	16 9	93 25	−·0036	+·0013	−·0002	+ ·157	+·020	+·015
γ Herculis	17	70 35	−·0032	+·0017	+·0004	− ·045	+·003	−·007

Star.	Approx. R.A.	Approx. N.P.D.	P.M. Right Ascension. Greenwich	Greenwich minus Auwers.	Greenwich minus Newcomb.	P.M. North Polar Distance. Greenwich	Greenwich minus Auwers.	Greenwich minus Newcomb.
	h m	° ′	s	s	s	″	″	″
Antares	16 23	116 11	−·0009	+·0013	+·0003	+ ·046	+·018	+·017
λ Ophiuchi	25	87 46	−·0026	+·0001	−·0001	+ ·081	+·016	+·003
ζ Ophiuchi	31	100 21	+·0002	+·0009	·0000	− ·018	+·017	+·004
ζ Herculis	37	58 12	−·0365	−·0009	·0000	− ·385	+·025	+·007
κ Ophiuchi	53	80 27	−·0193	+·0019	+·0009	+ ·011	+·026	+·001
ε Herculis	56	58 55	−·0039	+·0008	−·0002	− ·039	−·007	−·015
η Ophiuchi	17 4	105 35	+·0023	+·0020	+·0011	− ·087	+·010	+·003
α^1 Herculis	10	75 29	−·0008	+·0011	+·0002	− ·042	−·012	−·014
θ Ophiuchi	15	114 53	−·0018	+·0006	−·0007	+ ·030	−·005	−·004
σ Ophiuchi	21	85 46	+·0009	+·0026	+·0011	− ·003	+·012	+·005
α Ophiuchi	30	77 22	+·0081	+·0015	+·0004	+ ·230	+·013	−·005
β Ophiuchi	38	85 23	−·0023	+·0018	+·0006	− ·157	+·010	−·001
μ Herculis	42	62 13	−·0248	−·0004	−·0009	+ ·727	−·018	−·024
89 Herculis	51	63 56	+·0009	+·0006	−·0001	− ·017	−·008	−·012
72 Ophiuchi	18 2	80 27	−·0032	+·0024	+·0015	− ·087	+·002	−·003
μ Sagittarii	7	111 5	−·0004	+·0010	+·0005	+ ·013	+·014	+·010
η Serpentis	16	93 0	−·0377	+·0023	+·0004	+ ·707	+·030	+·023
λ Sagittarii	21	115 29	−·0053	−·0001	−·0015	+ ·184	−·014	−·020
α Lyræ	33	51 19	+·0183	+·0010	+·0007	− ·284	+·011	−·007
2 Aquilæ	36	99 9	+·0008	+·0012	−·0008	− ·004	+·001	−·013
β^1 Lyræ	46	56 46	+·0006	+·0013	+·0004	+ ·009	+·026	+·001
ε Aquilæ	55	75 5	−·0037	+·0012	+·0007	+ ·085	+·005	+·001
ζ Aquilæ	19 0	76 18	−·0003	+·0023	+·0007	+ ·096	+·007	−·008
ψ Sagittarii	9	115 27	+·0032	+·0028	+·0011	+ ·040	+·011	+·001
ω Aquilæ	13	78 36	·0000	+·0014	+·0005	− ·011	+·014	−·001
δ Aquilæ	20	87 6	+·0176	+·0023	+·0012	− ·081	+ 010	−·004
α Vulpec.	24	65 33	−·0092	+·0016	+·0006	+ ·103	+·001	−·011
μ Aquilæ	29	82 51	+·0145	+·0016	+·0003	+ ·155	+·022	+·005
h^2 Sagittarii	30	115 8	+·0029	+·0013	−·0011	+ ·021	+·011	−·011
e^1 Sagittarii	34	106 33	+·0027	+·0001	−·0014	+ ·038	−·001	−·014
γ Aquilæ	41	79 39	+·0010	+·0015	+·0005	+ ·004	+·012	−·003
α Aquilæ	45	81 25	+·0363	+·0012	+·0007	− ·372	+·012	+·001
β Aquilæ	50	83 52	+·0026	+·0019	+·0004	+ ·469	−·004	−·017
c Sagittarii	56	118 1	+·0020	+·0016	+·0001	− ·003	+·021	+·005
θ Aquilæ	20 6	91 9	+·0023	+·0024	+·0007	− ·011	+·003	−·010
a^2 Capricorni	12	102 53	+·0036	+·0014	−·0001	+ ·003	+·020	+·020
β Capricorni	15	105 8	+·0023	+·0015	−·0004	− ·002	+·020	·000

Star.	Approx. R.A.	Approx. N.P.D.	P.M. Right Ascension. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.	P.M. North Polar Distance. Greenwich.	Greenwich minus Auwers.	Greenwich minus Newcomb.
	h m	° ′	s	s	s	″	″	″
ρ Capricorni	20 23	108 11	−·0017	+·0011	+·0001	+·030	+·023	+·004
Σ Delphini	28	79 4	+·0001	+·0007	−·0003	+·027	+·005	−·003
α Delphini	35	74 29	+·0045	+·0014	+·0001	+·002	·000	−·011
ε Aquarii	42	99 54	+·0018	+·0020	+·0005	+·039	+·012	+·003
μ Aquarii	47	99 24	+·0027	+·0019	+·0005	+·030	−·001	−·015
32 Vulpec.	50	62 22	−·0003	+·0013	+·0001	−·010	−·012	−·011
θ Capricorni	59	107 40	+·0057	+·0017	+·0010	+·066	+·012	−·006
ζ Cygni	21 8	60 13	+·0004	+·0019	+·0008	+·050	−·016	−·018
α Equulei	10	85 12	+·0043	+·0022	+·0013	+·088	+·010	−·003
ι Capricorni	16	107 18	+·0017	+·0020	−·0003	+·007	+·020	+·005
β Aquarii	26	96 3	+·0020	+·0026	+·0012	+·006	+·005	−·010
ξ Aquarii	32	98 21	+·0076	+·0018	+·0004	+·021	−·001	−·011
ε Pegasi	39	80 38	+·0011	+·0003	−·0001	−·003	+·008	+·010
δ Capricorni	41	106 38	+·0171	+·0005	−·0001	+·313	+·016	+·010
16 Pegasi	48	64 36	−·0002	+·0003	−·0005	−·009	−·011	−·009
α Aquarii	22 0	90 51	+·0006	+·0014	·0000	+·009	+·0 1	·000
ι Pegasi	2	65 12	+·0222	+·0013	+·0002	−·043	−·023	+·028
θ Aquarii	11	98 20	+·0076	+·0019	+·0006	+·033	+·014	+·008
γ Aquarii	16	91 56	+·0075	+·0007	−·0002	+·002	+·019	+·011
σ Aquarii	25	101 14	−·0008	+·0003	−·0004	+·027	−·010	−·005
η Aquarii	30	90 41	+·0057	+·0015	+·0004	+·063	+·010	+·004
ζ Pegasi	36	79 45	+·0045	+·0001	−·0007	+·010	−·008	−·011
μ Pegasi	45	65 59	+·0100	+·0004	−·0008	+·035	−·007	−·013
λ Aquarii	47	98 10	+·0005	+·0021	+·0007	−·026	+·014	+·002
Fomalhaut	52	120 12	+·0249	+·0017	·0000	+·179	+·020	·000
α Pegasi	59	75 23	+·0037	+·0009	−·0001	+·036	+·006	−·010
γ Piscium	23 11	87 19	+·0499	+·0012	+·0001	−·021	−·004	−·007
κ Piscium	21	89 20	+·0057	+·0016	+·0004	+·088	−·014	−·012
ι Piscium	34	84 58	+·0244	+·0010	+·0001	+·433	−·010	−·008
δ Sculptoris	43	118 44	+·0073	...	−·0021	+·137	...	+·003
ω Piscium	54	83 45	+·0097	+·0010	−·0002	+·107	−·001	−·006
2 Ceti	58	107 57	+·0009	+·0010	−·0002	+·026	+·031	+·006

The two following tables give the differences between the Greenwich system of proper motions and those of Auwers and Newcomb for each hour of right ascension, and for each 5° of N.P.D. from 60° to 120°. The first group extends to 10°, on account of the paucity of stars. Equal weight has been given to each star :—

Corrections to Auwers' and Newcomb's Systems of Proper Motions, arranged in order of R.A.

R.A.	No. of Stars.	P.M. in R.A. Gr.—A.	P.M. in R.A. Gr.—N.	P.M. in N.P.D. Gr.—A.	P.M. in N.P.D. Gr.—N.
h		s	s	"	"
0	11	+·00090	·00000	+·0082	−·0006
1	7	+·00131	+·00020	+·0145	−·0012
2	10	+·00143	+·00014	−·0003	−·0047
3	10	+·00112	−·00007	+·0043	−·0006
4	8	+·00111	+·00033	+·0001	−·0070
5	9	+·00150	+·00051	−·0004	−·0048
6	11	+·00046	−·00036	+·0100	+·0052
7	8	+·00068	+·00006	+·0083	+·0007
8	7	+·00077	−·00010	+·0060	−·0021
9	8	+·00081	−·00001	+·0074	−·0010
10	8	+·00124	−·00022	+·0032	−·0048
11	8	+·00108	−·00004	+·0073	−·0018
12	9	+·00063	−·00055	+·0013	−·0035
13	7	+·00086	+·00012	+·0050	−·0004
14	9	+·00131	+·00029	−·0029	−·0068
15	9	+·00124	+·00035	−·0059	−·0076
16	8	+·00089	+·00014	+·0147	+·0028
17	8	+·00123	+·00022	+·0002	−·0068
18	8	+·00129	+·00024	+·0094	−·0009
19	12	+·00163	+·00030	+·0098	−·0046
20	10	+·00154	+·00022	+·0082	−·0031
21	8	+·00145	+·00034	+·0038	−·0058
22	11	+·00112	−·00002	+·0042	−·0038
23	5	+·00116	+·00004	+·0004	−·0060

Corrections to Auwers' and Newcomb's Systems of Proper Motions, arranged in order of N.P.D.

N.P.D.	No. of Stars.	P.M. in R.A. Gr.—A.	P.M. in R.A. Gr.—N.	P.M. in N.P.D. G .—A.	P.M. in N.P.D. Gr.—N.
° °		s	s	"	"
50–60	10	+·00038	+·00009	+·0119	−·0051
60–65	15	+·00101	+·00024	−·0112	−·0130
65–70	21	+·00087	+·00004	+·0002	−·0037
70–75	17	+·00100	+·00008	−·0012	−·0088
75–80	23	+·00102	−·00010	+·0069	−·0009
80–85	26	+·00124	+·00018	+·0092	·0000
85–90	20	+·00183	+·00045	+·0024	−·0027
90–95	16	+·00144	+·00023	+·0066	+·0017
95–100	19	+·00148	+·00025	+·0060	−·0014

N.P.D.	No. of Stars.	P.M. in R.A. Gr.−A.	P.M. in R.A. Gr.−N.	P.M. in N.P.D. Gr.−A.	P.M. in N.P.D. Gr.−N.
° °		s	s	″	″
100–105	10	+·00117	−·00011	+·0107	+·0052
105–110	18	+·00071	−·00024	+·0089	+·0007
110–115	7	+·00057	−·00037	+·0084	+·0030
115–120	7	+·00117	−·00031	+·0107	−·0013
Mean	209	+·00112	+·00008	+·0050	−·0028

From the above comparison it would appear that the system of proper motions in Newcomb's new Fundamental Catalogue of Right Ascensions are practically identical with those that have been deduced as the Greenwich system of proper motions, while the correction to Auwers' system of proper motions indicates an erroneous epoch correction applied to the Bradley observations. With regard to the North Polar distances the Greenwich mean results stand almost midway between those of Auwers and Newcomb. There is a distinct run in the results both of R.A. and N.P.D. arranged in order of N.P.D., the error of which, on the average, for the Greenwich results would only amount to $\pm 0^{s}\cdot 01$ or $\pm 0''\cdot 12$ in the observed places at the extreme ranges. The result of the group in N.P.D. under the heading N.P.D. 60°–65° is distinctly anomalous, but most consistent. To hazard an explanation one would be inclined to suggest Bradley division errors.

In *Monthly Notices*, lvi. p. 6, I deduced the proper motions of some 45 fundamental stars from the Greenwich Observations, 1836–93; those in right ascension are affected by the systematic errors referred to above, and are not compared; but those in N.P.D., which are based on the same system of reductions, are compared in the following table, and the differences exhibited as corrections to Newcomb's system :—

Comparison between the Proper Motions in North Polar Distance derived from the Greenwich Observations, 1836–93 (*Monthly Notices*, vol. lvi. p. 6) (Gr_{57}), *and from the Greenwich Transit Circle*, 1854–96 (Gr_{42}).

Star.	$Gr_{57}-N.$	$Gr_{42}-N.$	Star.	$Gr_{57}-N.$	$Gr_{42}-N.$
	″	″		″	″
α Andromedæ	−0·013	−0·019	η Boötis	−0·006	−0·004
γ Pegasi	−·003	−·007	Arcturus	−·006	−·011
μ Andromedæ	−·006	−·010	ϵ^{2} Boötis	−·003	−·007
β Andromedæ	−·011	−·012	α Coronæ	−·003	−·015
α Arietis	+·002	−·008	α Serpentis	−·003	−·006
α Ceti	−·010	−·002	ζ Herculis	+·005	+·007
Aldebaran	−·005	−·011	α Herculis	−·002	−·014
Rigel	−·005	−·007	α Ophiuchi	−·004	−·005
β Tauri	−·010	−·019	α Lyræ	+·002	−·007
α Orionis	−·004	−·001	β Lyræ	−·001	+·001

Star.	$Gr_{57}-N.$	$Gr_{42}-N.$	Star.	$Gr_{57}-N.$	$Gr_{42}-N.$
	"	"		"	"
Castor	+ ·013	+ ·011	γ Aquilæ	+ ·005	− ·003
Procyon	− ·005	+ ·005	α Aquilæ	+ ·009	+ ·001
Pollux	+ ·001	− ·002	β Aquilæ	− ·005	− ·017
Regulus	+ ·006	− ·004	α^2 Capricorni	+ ·016	+ ·020
β Leonis	+ ·006	− ·003	α Aquarii	− ·011	·000
Spica	+ ·002	+ ·011	α Pegasi	·000	− ·010
			Mean	− ·0015	− ·0049

Apparently the longer system of observations gives results more accordant with those of Newcomb, but the difference in mean results points to a certain amount of discordance between the transit circle and mural circle observations.

The results of this paper appear to confirm the theory that the greater accuracy of modern instruments counterbalances the advantages of the older observations in point of time, and afford evidence of the limits of accuracy which can be attained in determining proper motions from different groups of well observed star places.

LEEDS PHILOSOPHICAL AND LITERARY SOCIETY.

Observations of Comet b 1898 (*Perrine*), *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations were made with the Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 55.

1898.	Greenwich Mean Solar Time. d h m s	Observer.	✐−✱R.A. m s	Corr. for Refraction. s	Log. Factor of Parallax.	✐−✱N.P.D. ′ ″	Corr. for Refraction. ″	Log. Factor of Parallax.	No of Comps.	Apparent R.A. h m s	Apparent N.P.D. ° ′ ″	Comp. Star.
Apr.	15 14 42 16	B.	−2 4·61	−0·01	9·6805	−7 32·0	−0·3	0·7780	4	23 12 56·52	48 21 20·6	*a*
	22 13 42 48	W.	+0 13·84	−0·01	9·6625	−4 7·4	−0·3	0·8313	6	23 48 51·04	43 42 7·3	*b*
	22 14 2 44	S.	−0 18·15	+0·01	9·6826	+5 29·1	+0·3	0·8110	6	23 48 57·60	43 41 34·1	*c*
	23 14 26 31	B.	−0 50·54	−0·01	9·7051	−5 43·0	−0·2	0·7833	3	23 54 20·68	43 5 56·0	*d*
	23 14 31 32	,,	−0 12·05	+0·01	9·7084	+7 42·6	+0·3	0·7772	3	...	...	*e*
	30 14 4 56	S.	+1 46·75	+0·01	9·7084	+7 1·2	+0·4	0·8042	8	...	...	*f*
	30 14 4 56	,,	+1 14·77	0·00	9·7084	−0 13·9	0·0	0·8042	8	...	...	*g*

LEEDS PHILOSOPHICAL AND LITERARY SOCIETY.

Notes.

The observations are corrected for refraction, but not for parallax. They are also corrected for the error of inclination of the wires and for the motion of the comet.

Apr. 15.—The comet was bright with a fairly large nucleus, and a tail over $\frac{1}{2}^{\circ}$ in length in north preceding direction.

Apr. 23.—The comet was still bright, but the tail was not so conspicuous as on Apr. 15.

The initials B., S., W. are those of Mr. Bryant, Mr. Showell, and Mr. Witchell respectively.

Comparison Stars.

	Star's Name.	Assumed R.A. 1898·0. h m s	Assumed N.P.D. 1898·0. ° ′ ″	Authority.
a	10 Andromedæ	23 15 1·01	48 28 50·2	Greenwich Ten-year Catalogue 1890 (MS.).
b	O. A. (N.), 26141	23 48 37·13	43 46 13·6	Bonn Astr. Gesell. Catalogue.
c	Lal. 46852	23 49 15·67	43 36 3·3	,, ,, ,,
d	O. A. (N.), 26274	23 55 11·15	43 11 38·1	,, ,, ,,
e	B.D. + 46°, No. 4226	23 54 25	42 57	Bonn Observations, vol. v.
f	B.D. + 50°, No. 106	0 30 16	39 29	,, ,,
g	B.D. + 50°, No. 108	0 30 50	39 35	,, ,,

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1898 *May* 12.